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(Including the Reports of the Imperial Dairy Expert, Physiological Chemist and Sugarcane Expert)

1932-33

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Scientific Reports of the Imperial Institute of Agricultural Research, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist and Sugarcane Expert)

1932-33

REPORT OF THE DIRECTOR

(W. McRae, M.A., D.Sc., F.L.S., I.A.S. ; and F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., I.A.S.)

I. RESEARCH AND PROGRAMME OF WORK

Soil Fertility

Of the principal plant-food materials in which the soils of India are deficient, by far the most important is nitrogen, and the manurial problem is, in the main, one of nitrogen deficiency. Depending, as India does almost exclusively, on the recuperative effects of natural processes in the soil to restore the combined nitrogen annually removed in the crops, studies of the nitrogen balance sheet, the factors influencing nitrogen fixation, and practical measures such as the use of leguminous crops and green manures are of great interest and importance.

The influence of leguminous crops in conserving the soil nitrogen when grown in mixture with a cereal is being tested by the Bacteriological Section for the last three years. As in previous years, the figures for total nitrogen remaining in the soil at the end of two years were less than at the beginning of the experiment in the *rabi* series, but in the *kharif* series they were higher. A gain is noticed in all plots in both series when the nitrogen removed in the crops is taken into account. The highest gain calculated in this way is 363 lb. per acre with a mixed crop of maize

and *urid* (*Phaseolus radiatus*) grown in the *kharif* season and 360 lb. per acre in the *rabi* series with maize and field peas grown in rotation. It appears that in certain years, if the season is favourable, maize plants may produce a greater amount of root secretion in the soil and there may be a greater accumulation of nitrogen at some seasons because of the stimulation of nitrogen-fixing organisms by such maize root secretions. It has incidentally also been observed that there is a seasonal fluctuation in nitrogen of the soil, that in April, May and June the *Clostridium* species of nitrogen-fixing organisms are predominant especially after the rains or when moisture is added to the soil, that organisms of the azotobacter type do not appear to multiply as rapidly as the *Clostridium* species, and that below the depth of one-fourth to three-fourths of an inch few azotobacter cells are present.

The field experiment started two years ago to find cheaper but equally efficient alternatives to sann-hemp as a green-manure will have to be run continuously for some years more before definite conclusions can be obtained, as the third year's results have revealed that the experimental area selected is not of uniform fertility. The experiment on the possibility of securing green-manure from land already growing another crop has been transferred to comparatively poor land. As in the previous year, but on poorer land, Mexican sunflower was planted along with onions. Expressed in yields per acre 51·6 maunds of onions and 230 maunds of sunflower (sufficient to manure one acre of land) were obtained, as against 89 mds. of onions from control plots growing that crop alone. It remains to be seen whether, as in the case of the richer land of the previous year, yields of subsequent crops would compensate for the loss in onions.

Apricot seed-cake, largely available in Simla Hills and at present mainly used as fuel, having been found to contain 6·7 per cent. nitrogen, 60 per cent. of which is in available form, pot experiments have been started with Pusa soil to which 20, 40, 80 and 100 lb. of nitrogen per acre are added in the form of cake, the crop grown being wheat. The application of 80 lb. of nitrogen gave practically the maximum crop production, and *Eleusine coracana* has been sown in the *kharif* to study the residual effect of the manure.

Among other investigations bearing on the maintenance or improvement of the fertility of soils may be mentioned those intended to elucidate the lime requirements of acid soils, the limiting factor of phosphate requirements in calcareous soils, the apparent ineffectiveness, or even depressing, effect of potassic fertilizers in Pusa soil, and the conditions under which the insoluble phosphate contained in apatite, called kudada phosphate, could be made available to the crops.

The Quality of Agricultural Produce

The quality of agricultural produce depends upon its uniformity, its purity and its possession of some intrinsic property, *e.g.*, high gluten content in wheat, oil-content in linseed, disease resistance in pigeon-pea. The spread of pure line seeds by the Agricultural Departments places a uniform product in the hands of the cultivator, and the maintenance of purity in the crop depends on the extent to which it is in the power of the ryot to carry out harvesting and sowing with some approach to modern methods. Improvement in any intrinsic property of a crop is the work of the plant-breeder and this section of the report is mainly concerned with what is being done at Pusa in this respect.

Wheat. Further proof of the outstanding quality of Pusa wheats has been received from Rhodesia where a prize for the best bag of seed wheat was won with Pusa 4. This variety is now extensively grown in New South Wales, and the Director of Plant Breeding in that State reports that it is among the 20 leading varieties grown there. Pusa 111, which did so well in milling and baking tests made in the United States of America as well as by the Research Association of British Flour Millers, is reported to be promising in comparison with Pusa 4. The wheat breeding work with tha hybrids between Federation and Pusa 4 and Federation and Puse 52 has now reached the stage at which yield trials are being conducted with the more promising hybrids. One of the hybrids (No. 1054) has been found in the U. S. A. resistant to five physiological forms of *Puccinia triticina*. Two late maturing hybrids having given very good results in the preliminary tests at Karnal are now known as P. 120 and P. 165. Large-scale tests with these hybrids in comparison with the standard Pusa and Punjab types will be made next year simultaneously at Pusa, at Karnal, and at several farms in the Punjab and the United Provinces under various climatic and other conditions including canal-irrigated, well-irrigated, and rain-fed lands. Some crosses with P. 111 as a parent promise to give at Karnal a bearded variety with the grain qualities of P. 111.

Barley. The purplish tinge on the seed surface of the heavy-yielding and plump-grained Type 21 isolated at Pusa renders it unsuitable for malting and brewing purposes. Hybridization has therefore been resorted to to evolve a strain combining the high yielding power of Type 21 parent and the white colour of the seed of the other parent, and some F_2 and F_3 generations studied during the year promise to provide the desired type.

Tobacco. As mentioned in previous reports, the problem of meeting the ever-increasing demand for a lighter and brighter tobacco is being tackled in the Botanical Section which has, by crossing a local type (Type 28) with an American Adcock, evolved hybrids which are now fixed and are breeding pure within narrow

limits. The progress of investigation in curing and yield was seriously hampered by the damage done by frost to the tobacco crop of the year under review. The system of flue-curing evolved at Pusa is, however, being widely adopted and the progressive tobacco-growing tracts are now dotted over with barns owned by ryots. The Chemical Section is continuing work on the relation of the changes taking place during various methods of curing in the quality of the cured leaf. After having established that the method of curing by picking the leaves from the stalk is more expensive and requires more space than the method of curing the leaves with stalks on and that leaves with stalks on are richer in nicotine content, the investigation was extended to determination of the albuminoid-amide and ash-potash ratios which along with nicotine have been recognized by several investigators as having a direct bearing on the quality of tobacco. A lower ratio in both cases is indicative of a better quality, but the year's results show that curing of leaves with stalks on though invariably tends to lower the albuminoid-amide ratio, in most cases it raises the ash-potash ratio.

Pigeon-pea. In a yield trial with the most promising types isolated, Types 15, 24, 51 and 64 proved significantly better than local seed. Type 51 is erect in habit and possesses a large yellow-brown seed and is also wilt-resistant. These characters together with its high yielding capacity should make this type of great economic importance. At the Etawah Agricultural Station (United Provinces), it gave an average outturn of 2,228·5 lb. per acre, and the Farm Superintendent reports that the crop was very little affected by frost in the month of January while local pigeon-pea in the adjoining fields of cultivators was badly damaged.

Indigo. One of the principal disadvantages under which natural indigo has to compete with synthetic indigo is that the former is sold in the form of dry cakes which have to be converted into a paste before being used for dyeing purposes, while the latter is sold as readily available paste. With a view to bring the natural product in line with the synthetic dye, experiments have been started in the Chemical Section on the standardization of natural indigo paste and its prevention from fermentation. Indigo paste prepared from cake powdered into a very fine state and mixed with water of equal weight, when treated with 1·5 per cent. sodium carbonate and heated in air oven at a temperature of 105 C. for 12 to 15 hours, has remained unchanged and free from fermentation for three months in sealed tins. It is proposed to extend the investigation to indigo paste available in indigo factories before its conversion into cakes.

In the case of other crops such as oats and sugarcane, the improved varieties evolved are distinguished by the superior quality of their produce, but as their value lies mainly in the

high acreage yields obtained, they are referred to in the succeeding section dealing with improvement of the yield of agricultural produce.

Breeding Improved and Higher Yielding Varieties

The work of breeding high yielding types of Indian crops constitute an important part of the duties of the Botanical Section and furnishes a source of practical training for the students. The success achieved by the Pusa varieties of crops and by the Coimbatore canes affords a measure of what has been and is being achieved.

Barley. Type 21 is maintaining its reputation as a high yielding barley ; in North Bihar at Sepaya it gave an average yield of 1,868 lb. per acre in an area of 8·5 acres, beating the local barley significantly by 31 per cent., and at Gungowli the yield averaged 2,870 lb. This type has been adopted by the Deputy Director of Agriculture, Muzafferpur, for large-scale distribution of seed. Even under irrigated conditions in the United Provinces, when tried at four centres, it did better than the best form isolated by the local Department of Agriculture (Cawnpore Type 251) except at Raya in the Muttra District :—

Yield per acre

	Muzaffer-nagar	Cawnpore	Raya	Etawah
Pusa Type 21 . .	3,290·5	3,115·4	3,678·8	3,755·6
Cawnpore Type 251 .	2,714·0	2,489·0	3,826·0	..

Some Pusa barleys supplied to the Department of Agriculture, Victoria, Australia, are reported to be the most promising, among more than 100 importations from numerous countries, for use as parent-material. Types 12 and 20 have been mated there with Pryor and Plumage Archer for the early malting varieties, and with Cape for early feed. In addition, Type 24 is to be used for the production of an early feed type suited to the drier areas of the State.

Oats. The 12 hybrids fixed by crossing Pusa types with Abundance and Scotch Potato varieties were again tried simultaneously at Pusa (without irrigation) and Karnal (under irrigation) against the standard Pusa Types B. S. 1 and B. S. 2, and promising and interesting results were obtained. They will be repeated for the third time in the ensuing season, and it is hoped that the response of different types to variations in soil and climate will be elucidated by these trials. In a varietal trial at Sepaya in Bihar and Orissa,

the average yield of 2,854 lb. grain per acre given by B. S. 1 was superior to that of Hybrid C by about 30 per cent. On the other hand, at Raya in the United Provinces the outturn of green fodder per acre was 34,460 lb. in the case of Hybrid C as compared with 27,675 lb. yielded by B. S. 1.

Linseed. Of the hybrids obtained by crossing the high-yielding Pusa Types 12 and 121 of low oil-content with certain low-yielding Central Indian varieties of high oil-content, two, *viz.*, H. 55 and H. 21 have been found equal to the standard Type 12 in yielding power and to possess considerably higher oil percentage.

Variety	*Oil percentage*					
	1928-29	1929-30	1930-31	1931-32	1932-33	Mean.
Type 12	36·67	36·93	37·68	37·29	37·74	37·26
Hybrid 55 (T. 8 × T. 121)	44·03	40·26	42·23	44·73	42·78	42·81
Hybrid 21 (T. 12 × T. 8)	41·80	39·74	37·66	42·20	38·88	40·05

Both these hybrids have the ' white ' seed colour which is more popular with the trade than the dark.

Gram. Extended trials at Pusa and Karnal have confirmed that in Type 58 we have definitely obtained a gram superior in yielding power to the established varieties. Similar trials are being organized in Sind, the Punjab and the United Provinces in collaboration with the local Departments of Agriculture. The other promising among the new types are Types 53, 54, 55 and 67.

Many other crops are also under investigation, for full details of which and of the numerous points of general interest connected with the work, reference should be made to the Report of the Botanical Section.

Sugarcane. For climatic reasons, breeding work on canes is done at Coimbatore by the Sugarcane Expert and his staff. It is now being supplemented at the Sub-station at Karnal financed by the Imperial Council of Agricultural Research where both crossed and selfed seeds obtained from the crosses made at Coimbatore are being successfully germinated. The improved types of thin and sub-tropical canes bred at Coimbatore have replaced the local types on 39 per cent. of the total acreage, and their high tonnage and greater sugar content have been one of the principal factors in the development of the indigenous white sugar industry which promises by 1934-35 to make India independent of foreign imports which were valued at Rs. 15·5 crores in 1929-30. No tariff however highly pitched would have brought into existence 27 new sugar factories in the United Provinces and Bihar and Orissa

during the year under report, had not improved varieties of cane been available to supply the requisite raw material without any very appreciable increase in the total acreage under the crop. Certain of these sub-tropical canes are now spreading in typically tropical parts of Madras where even a comparatively thin medium cane like Co. 281 has yielded in certain localities higher tonnages than a very thick type like Badila. The chief value of this class of canes in areas under thick types lies in lowering the cost of production—not a small consideration when the prices of agricultural produce have fallen so low. The breeding of new seedlings which will give heavy yields under a wider range of conditions than those for which the present popular Coimbatore varieties are suitable is being actively carried on. Among the new canes, Co. 313 and Co. 331 are the most promising, followed closely by Co. 299, Co. 326, Co. 301, Co. 244 and Co. 300. Co. 285 is justifying expectations entertained at the time of selection as likely to be an improvement on and replace Co. 205. In the farm at Patna this cane has shown considerable resistance to water-logging. Experience on the Karnal Sub-station indicates that Co. 312, Co. 357 (a sugarcane-sorghum hybrid) and Co. 313 are easily superior not only to the local Lalri but also to Co. 205 and Co. 285 which are displacing the local variety.

The work on thick or tropical canes was started more recently and the first batch of seedlings of the thick type was distributed only a couple of years ago, but satisfactory reports have already been received of the performances of Co. 402 and Co. 408 at various stations. In the preliminary test plots at Coimbatore, there are a number of later seedlings which promise to do better than the above-mentioned two canes.

Sugarcane-sorghum hybrids. The crossing of P. O. J. 2725 sugarcane with *Sorghum Durra*, with a view to obtaining a sugar-giving plant with a shorter growing period than sugarcane, has provided selected hybrids possessing certain common characteristics, *viz.*, fitness for milling after a growth of six to seven months, improvement in sucrose values when kept in the field for a longer period and comparatively high purities. One of these hybrids has recorded over 23 per cent. sucrose in juice and a second over 21 per cent. In the Madras Presidency, where on certain stations the hybrids are planted every month and analysed periodically to find out the best way of fitting these short-duration canes into the agricultural programme of the tract, Co. 352 planted at Anakapalle on the 1st September, 1931, and harvested on the 9th April, 1932, analysed as follows:—Brix 20·47 per cent., sucrose 17·90 per cent., glucose 0·31 per cent. and co-efficient of purity 87·46. As the F_1 generation obtained by crossing P. O. J. 2725 sugarcane with *Sorghum Durra* often includes a number of types which nestle close to the ground, show limited cane formation, possess thick leaves and are obviously of no value as sugarcanes, the range of parents on

either side has been extended by including P. O. J. 213, Co. 213 and Co. 221 as mothers and *Sorghum guineense*, *S. cernuum*, *S. halepense*, *S. verticilliflorum* and *S. sudanense* as fathers. Though some of the original hybrids back-crossed with *Sorghum Durra* gave uneconomic types, the plants obtained by crossing them with *Saccharum sponta neum* were much like thin-stemmed sugarcanes.

At Pusa, an independent area of land measuring 150 acres is mainly devoted to sugarcane experiments. The testing of new Coimbatore canes for yield and other characteristics, tonnage trials with selected varieties, manurial experiments and general problems of cane cultivation form the basis of the work. The tests completed during the year indicate that Co. 299 is practically as early as Co. 214 and far superior to it in tonnage, that Co. 313 is another promising early variety, that Co. 331 represents the late cane required for crushing during April and May, and that Co. 285 is particularly suitable for water-logged areas. Work on Co. 281, as a cane suitable for irrigated areas under factory control, has now reached an estate scale and some 12 acres have been planted with it which, it is hoped, will definitely prove that an increased amount of sugar over the standard variety now irrigated can be obtained in a normal crop. Experiments with Co. 281 have shown that the damage caused to early ripening canes by jackals and pigs when left standing in the field for seed after the main crop is harvested, can be avoided by trashing of these canes for seed purposes.

Plant Diseases

In pursuance of the scheme for research on mosaic and other diseases of sugarcane financed by the Imperial Council of Agricultural Research, an intensive study of the mosaic virus has been taken up, and a new line of attack has been developed to find out the nature of the mosaic diseases, for details of which reference is invited to the Report of the Imperial Mycologist. Another year's results of the experiment to determine the effect of mosaic on the yield and juice of sugarcane indicate a loss, through mosaic, of four per cent. in juice. The occurrence of the red stripe disease caused by bacterial infection has been established for the first time in India. The causative organism has been isolated, and its bio-chemical reactions have been found to differ slightly from those of *Phytomonas rubrilineans* and *P. rubrisubalbicans* which are known to cause the red stripe in other sugarcane-growing countries. At Dacca and Sepaya, the disease has assumed serious proportions, the incidence being as much as 80 per cent. in some varieties. It does not kill the cane outright but the growth is checked, and in cases where the top shoot is affected there is appreciable loss. The species of *Fusarium* causing top-rot has been identified as *Fusarium moniliforme* and its parasitism established. The yellowing of

canes has been ascertained to be a deficiency disease, clumps manured with either potasium sulphate or ammonium sulphate reviving and assuming a healthy appearance.

Observations made in two consecutive years on the stem-rot disease of *Hibiscus subdariffa* caused by *Sclerotinia sclerotiorum* have shown that the disease appears in January, that the parasite develops the ascospore stage only in the cold weather and that infection is mainly due to these spores. It would therefore appear that varieties maturing by the time the disease appears would automatically escape infection, and attempts are being made to see if the type under study could be made to set seed a little earlier.

That kerol when applied to the soil in a concentration of 0·07 per cent. is effective in controlling foot-rot of *Piper betel* caused by *Rhizoctonia solani* and *Sclerotium rolfsii* was confirmed, and phenyl too in 1 and 0·5 per cent. strengths has proved an equally efficient soil disinfectant.

The experiment to test the comparative resisting power of 24 types of Pusa barleys to *Helminthosporium* together with the effect of uspulun as a seed treatment was repeated, and the efficiency of uspulun to control the disease was confirmed. It was incidentally proved that this fungicide also checks the attack by smut (*Ustilago hordei*).

With a view to controlling the seedling diseases caused by *Rhizoctonias* seed treatment was tried on chillies and tobacco. Mercury bichloride, uspulun, granosan and germisan were tested, and in each case excellent results were recorded, the dust treatment (granosan) giving better result.

Treatment of gram seed in a solution of either formalin or uspulun, or with sulphur or ceresan, and spraying of the crop with one per cent. Bordeaux mixture or dusting with colloidal sulphur RV3 are all being tried to control the leaf blight of gram caused by *Mystrosporium* sp. The experiment will have to be repeated for some years to obtain sufficient data to draw conclusions from.

Among other diseases under investigation may be mentioned, those of wheat caused by *Tilletia*, *Helminthosporium* and *Puccinia*, the *Sclerotium* disease of rice, the wilt disease of *Crotalaria juncea* and the stem-rot of tobacco. A survey of diseases of fruit trees in British Baluchistan was undertaken during the year and several fungi were recorded there for the first time.

Insect Attacks

As in previous years, sugarcane borers and other insect pests of sugarcane received considerable attention in the Entomological Section. Despite systematic destruction of egg-masses of the top-

shoot borer and removal of " dead-hearts " and damaged shoots and occasional treatment with 0·5 per cent. crude oil emulsion, the mean percentage of insect infection in mosaic tonnage experimental plots was slightly more than that of last year and as follows :—

Insects	Mosaic free plots	Mosaic plots
Top-shoot borers (*Scirpophaga nivella* Fabr.)—		
Early attack	10·9	10·5
Late attack	26·02	26·7
Stem-borers (*Argyria sticticraspis* Hmpn., *Diatraea venosata* Wlk., *Chilo zonellus* Swinh.) . .	4·35	4·36
Root-borer (*Emmalocera depressella* Swinh.) . . .	9·29	9·2
Termites	9·5	8·58

From samples taken at random, from cane fields in the New Area, the average loss in weight in mosaic-free Co. 213, caused by the top-shoot borer, was found to be 15·4 per cent. Among other cane pests under observation are *Pyrilla* spp., *Aleurolobus barodensis*, *Neomaskellia bergi*, *Gryllotalpa africana*, *Myllocerus discolor* and Elaterid grubs.

A preliminary survey of the various insect pests reported to be causing enormous damage to the fruit trees in Baluchistan was carried out with a view to devising control measures to be carried out by the local agency.

Poison baits consisting of sweetened bran mixed with barium carbonate were more successful than those containing potassium cyanide against rats causing damage in paddy fields and stored rice.

The linseed crop of the Botanical Section was attacked by a Cecidomyiad fly the pinkish larvæ of which were found feeding upon the pollen of the flowers in March 1933. A light trap was set up for about two weeks and a fairly good number of flies were killed. The incidence of *Agrotis ypsilon* was checked by poison baits.

The life-histories of about 80 insects were studied partly or fully, and some observations were made on the habits and habitats of the Asilidæ of Pusa.

The Spread of Improved Varieties of Crops

The work of the plant-breeder in evolving improved varieties of crops is obviously merely a means to an end, and the most direct proof of its value is given by the records of the amount of improved seeds, etc., distributed to growers. In the past season the Botanical Section and its Sub-station at Karnal, and the Agricultural Section at Pusa distributed to Provincial Departments of Agriculture and to private growers the following quantities of seed of improved varieties :—45,025 lb. of wheat, 7,860 lb. of barley, 7,826 lb. of oats, 10,310 lb. of gram, 2,430 lb. of pigeon-pea, 3,540 lb. of linseed, 24·5 lb. of tobacco, 255,533 lb. of sugarcane setts and 1,618 lb. of maize and miscellaneous. The Sugarcane Station at Coimbatore supplied preserved sugarcane seeds to the Economic Botanist at Shahjahanpur in the United Provinces and to the Sugarcane Specialist at Mushari in Bihar and Orissa. The Sugarcane Research Station at Shahjahanpur was also supplied with 5,000 seedlings of parentage likely to be useful in the United Provinces. In addition, 412 packets of seed canes were sent to various parts of India. These figures, large as they are, correspond to only a small fraction of the actual area covered by improved varieties bred at Pusa and Coimbatore, for the spread of improved seeds is mainly carried out by Local Departments of Agriculture who obtain yearly relatively small quantities of seed from Pusa and multiply this for distribution to ryots. For instance, of 1,059,840 maunds of seed distributed in the United Provinces in 1930-31, 80 per cent. was of sugarcane and 16 per cent of wheat, and the improved varieties of these crops adopted for departmental seed distribution are mainly those originally emanating from Coimbatore and Pusa respectively. The maintenance of the standard of improvement which the original introduction offered is of vital importance, and a regular system for maintaining the purity of the seed supply of the established Pusa wheats has been formulated in the Botanical Section. Seed is taken from typical single plants of each type every year and in the succeeding year is sown in five rows. Seed from the five rows is sown in a small plot in the next year and from this plot sufficient seed is obtained to sow one acre in the following year. From this, seed is given in the next season for sowing on ten-acre plots on the Pusa Farm. The crop on the Farm is therefore only four generations removed from a single plant and this seed is available for distribution to different Departments of Agriculture and others.

Agricultural Machinery

The Marshall Diesel tractor purchased in March 1932 had a full year's trial, and the results of the year's working have shown that the crude oil tractor is as easy to start, manipulate and work

as any kerosene oil tractor, and whether the agricultural operation carried out is ploughing, disc-harrowing or grubbing, the cost per acre is comparatively lower by more than 33 per cent. Investigations into the design of a small thresher suitable for Indian conditions and marketable at a price within the range of small landowners have resulted in a type which has successfully stood an exhaustive test. During 57·590 working hours over a period of 16 days, 239·860 maunds of grain were obtained, the average output per hour being 4·16 maunds.

Cattle Breeding and Dairying

Pusa. The new system of feeding and handling referred to in last year's report was worked throughout the year and the average yield of milk per day per cow in the pure bred Sahiwal herd was raised from 13·6 lb. to 17·9 lb. and the percentage of cows in milk increased from 50·2 to 55·1. In June 1933, the average yield per cow per day stood at the record figure of 19·2 lb. The previous herd record of 7,053 lb. in a lactation period of 10 months, which had remained unbeaten for seven years, was surpassed by six cows who gave 8,863, 8,081, 8,060, 7,901, 7,254 and 7,226 lb. respectively, and two heifers outdistanced the previous heifer record of 5,785 lb. achieved in 1921 by 1,863 and 1,234 lb. respectively. One cow which has been allowed to pass over the fixed lactation period of 304 days has done 9,746 lb. in 447 days and is giving 12 lb. daily at the time of writing. Without increasing the general expenses of the herd, the new system has resulted in an increase in the total milk yield by 47 per cent., a reduction in the service period, a steady rise in weight after reaching milking condition, and a steady maintenance of the average fat percentage of 4·7 in the milk yield throughout. Marked gains in body weight and more rapid maturity were obtained under a special system evolved for rearing pail-fed calves, and the mortality percentage was reduced from 4·3 to 1·4.

Karnal. Breeding work with two indigenous breeds, *viz.*, Hariana and Thar Parkar, on dual purpose lines is being continued. There has been steady improvement in milk yield, and records of over 8,000 lb. per lactation have been obtained in both herds. Systematic recording of fat percentage in the milk of individual cows has showed that the Indian cattle can yield as high percentage of fat as 7·8, and instances of animals with a 6·5 per cent. fat are quite common.

Bangalore. In addition to the original herd of Scindi cattle, a foundation herd of Gir cattle obtained from their original home in Kathiawar has been started in pursuance of the policy laid down by Government to concentrate attention on providing high yielding strains of indigenous breeds of cattle.

Animal Nutrition

An year's work by the Physiological Chemist on the influence of high and low protein feeding on milk production has not provided data from which definite conclusions can be drawn, but it appears that the composition of the milk is not perceptibly affected by the difference in feeding practice. There is also an indication, which requires confirmation, that the higher protein ration prolongs the lactation period slightly, which is suspected to have deleterious effects on the cows.

Various Indian coarse fodders are being tested for digestibility: feeding experiments with *juar* stalks in the prime stage as they came in from the field and with identical material converted into hay have shown that conversion into hay leads to a notable increase in the crude fibre fraction and corresponding serious lowering of digestibility of the carbohydrates. Experiments have also been undertaken to elucidate whether marked physical differences exist between the carbohydrates of such distinct products as rice straw, *ragi* (*E. coracana*) straw, sorghum and hay which possess distinct digestibility co-efficients. In view of the desirability of encouraging the production and utilization of legume hays an investigation into the best method of preparing them, their digestibility and their effect on the nitrogen balance has been undertaken.

The effect of supplementing a fodder ration with a mineral is being tested both with growing animals and adult bullocks. In the case of the former it has been noticed that 0·73 per cent. lime and 0·47 per cent. phosphoric acid in the basal ration suffice for normal growth. In the latter case the fodders used are rice straw and sorghum hay, and the mineral is calcium phosphate which at one stage was also supplemented by green food. Determinations of mineral balance have indicated that rice straw provides just enough phosphoric acid but not enough lime, while in sorghum hay there is a sufficiency of both lime and phosphoric acid. The results of both experiments have emphasized that a mineral supplement has no effect in cases where enough is present in the fodders themselves.

The object of another investigation is to determine comparative values of the mineral composition of grasses grown on selected typical soils in various parts of India. It has been observed that the protein content is a specific character and that the mineral contents vary with the stage of maturity, the dead ripe stage producing very poor quality.

In addition, various physiological studies are in hand, for which reference should be made to the Report of the Physiological Chemist.

Experiments undertaken on the Pusa Farm to arrive at the best method of preserving berseem in silo pits have shown that there

is least wastage when berseem and oats straw are placed in alternate layers in the proportion of 3 : 1 by volume, that green oats if available can also be used in place of oats straw, and that March and April cuts of berseem being less watery are most suitable for siloing and give better value. It is now possible to keep the Pusa milch herd for the whole year, if necessary, on a ration of either green berseem, berseem hay or berseem silage, and no other green fodder crop need be grown. The effect of treating berseem to be siloed with 0·1 per cent. hydrochloric acid or of adding about 10 per cent. molasses is being investigated in the Bacteriological Section.

II. GENERAL ADMINISTRATION

Charge. Dr. F. J. F. Shaw officiated as Director up to the 29th December 1932, when Dr. W. McRae resumed charge on relinquishing the officiating appointment of Agricultural Expert to the Imperial Council of Agricultural Research.

On reversion from the post of Director, Dr. Shaw took over the duties of Joint Director of the Institute from Mr. Wynne Sayer who was officiating in the post.

Staff. Owing to absences on leave, etc., the following changes in the charge of Sections were made :—

Mycological Section. Dr. M. Mitra up to the 29th December 1932, *vice* Dr. McRae on other duty.

Animal Nutrition Section. Mr. A. V. Iyer up to the 8th November 1932, *vice* Dr. F. J. Warth on leave.

Mr. T. Bainbrigge Fletcher who proceeded on leave with effect from the 6th April 1932, retired from the post of Imperial Entomologist on attaining superannuation age on the 25th March 1933. Mr. P. V. Isaac officiated as Imperial Entomologist throughout the year, and so did Mr. Wynne Sayer as Imperial Agriculturist. Messrs. J. N. Mukerji and N. V. Joshi, both Class II officers, continued to be in charge of the Chemical and Bacteriological Sections respectively.

Except in the case of certain specialized posts such as Cattle Superintendent, Statistician, etc., the designations of Assistant Mycologist, 2nd Assistant Mycologist, Assistant Agricultural Chemist, etc., have been adopted during the year for the gazetted officers of this Institute who are not in Class I Service.

Extensions. A beginning has been made in the organization of the new sub-section of statistics by the appointment of one computor, and the candidate selected by the Public Service Commission for the post of Statistician has since the close of the year entered upon his duties. The Commission has also made a selection for the post of Second Economic Botanist, and the

Botanical Section has been restored to its original strength of two Class I officers. The Imperial Council of Agricultural Research has sanctioned a grant of a sum of Rs. 31,200 for a five-year scheme for conducting research work on the genetics of sugarcane at the Imperial Cane-breeding Station, Coimbatore, and it is hoped that a start will be made with the scheme before the end of the current year when the Geneticist selected by the Public Service Commission will have taken up her duties.

Training. Provincial Committees for selection of students for post-graduate courses of the highest possible standard given at the Pusa Institute, foreshadowed in last year's report, have been constituted in some provinces, and of the 34 candidates applying for admission to the session beginning in November 1932, fifteen were the nominees of such committees. Sixteen applicants were selected for admission: seven in Botany, of whom two left subsequently on obtaining appointments, one in Entomology, two in Chemistry, three in Sugarcane Breeding, and three in General Agriculture. During the year under report four post-graduate students completed the two-year course at Pusa, three in Botany and one in Chemistry. The one-year course in farm organization, farm management and general farm engineering was completed by one student.

The fifteen-month post-graduate course in animal husbandry, animal nutrition and dairying was completed by one student in April 1933. Of the four applicants for admission to the new session beginning in January 1932, two were selected but one actually joined.

The class of 19 Indian Dairy Diploma students started in November 1931 was strengthened by the admission of one repeat course student. As the year under report was the intervening year no fresh admissions were made.

A number of students and post-graduate workers were also admitted for periods of work or training in various Sections of the Institute. A batch of 28 British soldiers took at the Bangalore Dairy Farm a six-month vocational course in practical dairying, and another batch of 15 soldiers was admitted on 1st June 1933 for a similar course. A special course of training in the flue-curing of tobacco lasting for six weeks was organized at Pusa, and, although there were a number of applicants, for want of accommodation only seven students could be admitted to it.

Library. Publications received in exchange numbered 1,941, while 461 were purchased. Of the 3,744 books, etc., issued on loan, 516 were to scientific workers in the provinces and universities. With a view to providing adequate storage space for the ever-increasing number of books in the library one additional room was fitted up with shelves during the year under report.

Buildings. The building programme at the Botanical Sub-station estimated to cost a total sum of Rs. 64,200, for which the Government had accepted liability, was completed, but no funds were available for any other major original work elsewhere.

Hospital. There were 341 in-patients and 5,117 out-patients in 1932, and 326 operations were performed. The health of the residents of the Estate was, on the whole, satisfactory.

III. ACCOUNTS

The total expenditure for the Institute and its out-stations during the financial year ending the 31st March 1933 amounted to Rs. 9,09,599, as against Rs. 11,89,001 for the previous year.

Name of establishment	Expenditure Rs.
General expenditure of the Institute, including the office of the Director, Power and Gas Plants, the Medical and Estate Establishments	1,98,013
Agricultural Section	1,31,978
Botanical Section	44,856
Chemical Section	34,968
Mycological Section	25,899
Entomological Section	53,919
Bacteriological Section	37,724
Imperial Dairy Expert	29,739
Bangalore Dairy	1,29,568
Wellington Dairy	39,560
Karnal Cattle Breeding Farm	70,987
Physiological Chemist, Bangalore	33,738
Sugarcane Station, Coimbatore	78,650
	9,09,599*

The cost of the Botanical and Sugarcane Sub-stations at Karnal and the scheme for research on mosaic and other diseases of sugarcanes amounting to Rs. 21,606, Rs. 20,312 and Rs. 12,140, respectively, was met from the funds of the Imperial Council of Agricultural Research.

*Provisional figure.

The receipts of the Institute and its out-stations amounted to Rs. 2,84,316* as shown below :—

——	Sale of dairy produce and live-stock	Sale of farm produce	Fees from students	Miscellaneous receipts	Total
Pusa Institute . .	21,884	19,101	3,525	11,315	55,825
Bangalore Dairy .	1,09,217	609	2,205	4,529	1,16,560
Wellington Dairy .	50,429	865	278	2,738	54,310
Karnal Farm . .	21,484	23,566	..	3,871	48,921
Coimbatore Sugarcane Station . .	..	..	..	..	8,800
TOTAL .	..	..	..	..	2,84,416

*Provisional figure.

REPORT OF THE IMPERIAL AGRICULTURIST

[Wynne Sayer, B.A., Dip. Agri. (Cantab.)]

I. CHARGE

Mr. Wynne Sayer was in charge of the Agricultural Section throughout the year. Mr. L. S. Joseph, Cattle Superintendent, was deputed for training in the post-graduate refresher course at the Imperial Institute of Veterinary Research, Muktesar, and Mr. S. M. Jamaluddin, Second Cattle Superintendent, was appointed to act as Cattle Superintendent during Mr. Joseph's deputation.

II. POST-GRADUATE TRAINING

One post-graduate student completed his training in general agriculture on the 31st October 1932. Three new post-graduate students for training in general agriculture (one from Bihar and Orissa, one from the United Provinces and one from the Punjab) and one post-graduate student from the Punjab for a two-year course in sugarcane research were admitted from the 1st November 1932. One post-graduate student from the Animal Husbandry and Dairying Section, who joined on the 16th December 1932, finished his training on the 30th March 1933.

III. SEED SUPPLY

The following seeds of the improved varieties of crops were distributed during the year :—

	lb.		lb.
Wheat Pusa 4	2,205·2	Barley T. 21	4,525·7
„ „ 12	1,603·0		
„ „ 111	503·4	Lentils T. III-86	534·9
„ „ 52	7,858·7		
„ „ 80—5	205·7		
	12,376·0	Linseed T. 121	345·6
		„ T. 124	329·1
		„ T. 12	637·7
Oats B. S. I	4,155·4		1,312·4
„ „ „ II	1,008·0		
	5,163·4		
		Maize No. 1	46·3
Pigeon-pea T. 69	82·3	„ No. 2	15·4
„ T. 16	20·3	„ No. 3	169·7
	102·6		231·4

	lb.
Soybean-Chocolate	102·9
Gram T. 58	715·9
„ T. 17	1,414·3
„ T. 25	442·8
„ No. 15	115·2
	2,688·2
Pea No. 1	54·8
„ No. 2	41·1
„ No. 4	2·1
	98·0
Sann-hemp	1·0
Cowpeas	82·3
Sugarcane Co. 210	267·4
„ Co. 213	2,108·6
„ Co. 214	13,350·9
„ Co. 281	2,715·4
„ Co. 285	207,052·2
Sugarcane Co. 299	3,497·1
„ Co. 300	3,970·3
„ Co. 301	4,608·0
„ Co. 312	493·7
„ Co. 313	3,929·1
„ Co. 318	2,427·4
„ Co. 326	864·0
„ Co. 331	4,443·4
„ Co. 335	288·0
„ Co. 336	164·6
„ Co. 341	576·0
„ Co. 342	3,126·9
„ Co. 345	82·3
„ Co. 346	905·1
„ Co. 351	41·1
„ Co. 352	123·4
„ Co. 353	82·3
„ Co. 355	164·6
„ Co. 356	164·6
„ Tuc. 393	41·1
„ Tuc. 472	41·1
„ P. O. J. 2878	4·1
	255,532·7

IV. CROP STATEMENT

The following statement gives the principal crops grown on the farm and yields obtained :—

Crop	Area in acres	Yield in maunds	
		Total	Average per acre
Sugarcane	47·04	24,849·80	528·05
Maize corn	115·20	1,690·35	14·67
Maize, green fodder	145·54	29,794·00	204·71
Wheat P. 4*	10·00	130·50	13·05
Wheat P. 12*	9·00	146·32	16·25
Wheat P. 52*	10·00	159·90	15·99
Other wheat varieties*	21·78	232·45	10·67
Barley T. 21	21·50	501·33	23·31
Arhar (*Cajanus indicus*)*	61·79	396·65	6·42
Peas*	22·28	118·23	5·31
Oats	186·94	3,476·60	18·59
Berseem†	58·77	15,133·75	257·51

*Crops damaged by frost.
† The figures for berseem include four cuts and no grazing.

V. EXPERIMENTAL WORK

The following experiments were conducted by the Agricultural Section during the year under report :—

1. *Manurial experiments*—

(*a*) Permanent manurial and rotation experiments.

(*b*) Randomised blocks laid down for check test experiments on the above treatments.

(*c*) Manurial experiments with double superphosphate on oats—one maund *versus* two maunds per acre.

(*d*) Green-manure experiments with sann-hemp, *guar* (*Cyamopsis psoralioides*), *meth* (*Phaseolus aconitifolius*) and cowpeas on oats.

(*e*) Green-manure and superphosphate experiments on oats.

(*f*) Manurial experiments with sulphate of potash and muriate of potash on berseem.

(*g*) Manurial experiments with superphosphate on sugarcane : 50 lb., 75 lb., 100 lb. P_2O_5 per acre.

(*h*) Manurial experiments with nitrogen on sugarcane : 40 lb., 50 lb. and 80 lb. nitrogen per acre in the form of oil-cake.

(*i*) Manurial experiments with superphosphate and oil-cake on sugarcane : 50 lb. P_2O_5 *plus* 40 lb., 60 lb. and 80 lb. nitrogen per acre.

(*j*) Manurial experiments with superphosphate and nitrogen (oil-cake) on sugarcane : 75 lb. P_2O_5 *plus* 40 lb., 60 lb. and 80 lb. nitrogen per acre.

(*k*) Manurial experiments with superphosphate and nitrogen (oil-cake) on sugarcane : 100 lb. P_2O_5 *plus* 40 lb., 60 lb. and 80 lb. nitrogen per acre.

(*l*) Manurial experiments with diammonphos and standard dressing (40 lb. nitrogen *plus* 50 lb. P_2O_5) on sugarcane.

(*m*) Manurial experiments with superphosphate and oil-cake on sugarcane : 100 lb. P_2O_5 and 80 lb. nitrogen per acre.

(*n*) Manurial experiments with oil-cake application—one dose *versus* two doses on sugarcane.

(*o*) Manurial experiments with sulphate of ammonia and nitrate of soda on sugarcane.

2. *Varietal yield trials with—*

(*a*) *Arhar.*

(*b*) Soybean.

(*c*) Maize for corn.

(*d*) Maize for fodder.

(*e*) Gram.

(*f*) Peas.

(*g*) Barley.

(*h*) Oats.

(*i*) Wheat.

(*j*) Sugarcane Co. 210 *versus* Co. 331.

(*k*) Sugarcane Co. 210 *versus* Co. 213.

(*l*) Sugarcane Co. 214 *versus* Co. 299.

(*m*) Sugarcane Co. 300, Co. 301, Co. 302, Co. 312 and Co. 316.

(*n*) Sugarcane Co. 210, Co. 213, Co. 214 and Co. 281.

3. *Experiments for other sections of the Institute—*

(*a*) Manurial experiments with various chemical manures on sugarcane for the Imperial Agricultural Chemist.

(*b*) Green-manure experiments for the Imperial Agricultural Bacteriologist—maize and wheat, sann-hemp and wheat, *urid* (*Phaseolus mungo*) and wheat, sann-hemp tops and wheat.

(*c*) Green-manure experiments with sann-hemp, sann-hemp tops, *urid* and soybean on wheat.

(*d*) Varietal trials with wheat for the Imperial Agricultural Bacteriologist—P. 52 *versus* country.

(*e*) Mosaic tonnage experiments with Co. 213 : healthy *versus* mosaic, for the Imperial Mycologist.

4. *Miscellaneous experiments—*

(*a*) Trashing for seed-cane with sugarcane variety Co. 281.

(*b*) Berseem silage investigations.

(*c*) Experiments to ascertain the effect of speed of tractor-drawn implements on soil tilth and crop yields.

(*d*) Spacing experiments with maize for corn.

(*e*) Sugarcane-cutting experiments with Co. 213 at Meghaul for ascertaining correct size of experimental plots.

VI. RESULTS OF FIELD AND OTHER EXPERIMENTS

1. Manurial Experiments

(*i*) *Permanent manurial and rotation experiments.* The experiment was continued on the same lines as before in the Punjab field, Blocks 'B' and 'D'. The following are the chemical analyses of manures applied to the experiment :—

Name of manure	N %	P_2O_5 %	K_2O %
Farmyard manure	0·72	0·50	0·48
Rape cake	5·65	..	..
Sulphate of ammonia	20·74	..	..
Sulphate of potash	..	..	48·42
Superphosphate	..	39·57	..

Wheat and *arhar* crops were damaged by frost and the effect was marked on certain plots in these experiments.

Results of permanent manurial and rotation experiments for the year 1932-33

Treatment	A SERIES			B SERIES	
	Kharif 1932	Rabi 1932-33		Kharif 1932	Rabi 1932-33
	Maize grain per acre in	*Arhar* grain per acre in	Barley grain per acre in	Maize grain per acre in	Wheat grain per acre in
Group I	lb.	lb.	lb.	lb.	lb.
1 No manure (Check plot No. 1).	337	1,339	..	716	339
2 Farmyard manure @ 4,000 lb. per acre.	838	1,224	..	1,215	555
3 Farmyard manure @ 8,000 lb. per acre.	1,306	1,191	..	1,618	686
4 Farmyard manure @ 4,000 lb. per acre *plus* rape cake to supply 20 lb. nitrogen per acre at the time of last interculture.	1,445	1,150	..	1,601	639
5 Rape cake @ 40 lb. nitrogen per acre, half to be applied just before *kharif* sowing and half to be applied at last interculture.	1,117	1,199	..	1,334	370

	Treatment	A SERIES			B SERIES	
		Kharif 1932	Rabi 1932-33		Kharif 1932	Rabi 1932-33
		Maize grain per acre in	*Arhar* grain per acre in	Barley grain per acre in	Maize grain per acre in	Wheat grain per acre in
		lb.	lb.	lb.	lb.	lb.
	Group II					
6	Sulphate of ammonia @ 40 lb. nitrogen per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown it is to be applied in one dose in *kharif*.	222	1,088	..	509	263
7	Sulphate of potash @ 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* crop is sown it is to be applied in one dose in *kharif*.	665	936	..	579	241
8	Superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown it is to be applied in one dose in *kharif*.	304	1,211	..	1,084	605
9	Sulphate of potash @ 50 lb. K_2O per acre and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	411	1,141	..	985	661
10	Sulphate of ammonia @ 40 lb. nitrogen, sulphate of potash @ 50 lb. K_2O and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	584	1,211	..	1,314	839

	Treatment	A SERIES			B SERIES	
		Kharif 1932	Rabi 1932-33		Kharif 1932	Rabi 1932-33
		Maize grain per acre in	*Arhar* grain per acre in	Barley grain per acre in	Maize grain per acre in	Wheat grain per acre in
		lb.	lb.	lb.	lb.	lb.
	Group II—*contd.*					
11	Sulphate of ammonia @ 40 lb. nitrogen and superphosphate @ 80 lb. P_2O_5 per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	140	1,577	..	1,002	704
12	No manure (Check plot No. 2).	107	640	..	302	261
13	Sulphate of ammonia @ 40 lb. nitrogen per acre, sulphate of potash @ 50 lb. K_2O per acre, half before *kharif* and half before *rabi* sowing, but in the year when *arhar* is sown they are to be applied in one dose in *kharif*.	246	402	..	370	326
	Group III					
14	Green manure in conjunction with a purely cereal rotation.	Green manure	..	859	Green manure	199
15	Effect of green manure and leguminous crop in the rotation.	805	230	..	Do.	702
16	As for plot No. 15 but with an additional application of superphosphate @ 80 lb. P_2O_5 per acre to be applied with green manure only.	994	665	..	Do.	1,987
17	No leguminous crop and no green manure.	747	..	402	649	252
18	No manure (Check plot No. 3).	575	411	..	706	425

(*ii*) *New manurial experiments*. The experiment was started with a view to obtain a statistically significant result from the manuring programme followed on the permanent manurial plots. It has been laid down in the Punjab field, Block A, in "Randomised Blocks" with 10 treatments and 10 replications. The area of each plot is 1/40 acre.

The following four-year eight-course cropping scheme will be followed :—

1. Maize and oats, 1932-33.
2. Maize and peas, 1933-34.
3. Maize and wheat, 1934-35.
4. Maize and gram, 1935-36.

The following are the ten treatments adopted in the experiment :—

A. No manure.

B. Farmyard manure at 8,000 lb. per acre. Total amount to be applied in the last week of April or first week of May.

C. Rape cake at 40 lb. nitrogen per acre, half to be applied just before *kharif* sowing and half to be applied at the time of last interculture.

D. Sulphate of ammonia at 40 lb. nitrogen per acre, half before *kharif* sowing and half before *rabi* sowing.

E. Sulphate of potash at 50 lb. K_2O per acre, half before *kharif* sowing and half before *rabi* sowing.

F. Superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* sowing and half before *rabi* sowing.

G. Sulphate of potash at 50 lb. K_2O per acre, and superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* sowing and half before *rabi* sowing.

H. Sulphate of ammonia at 40 lb. nitrogen per acre, superphosphate at 80 lb. P_2O_5 per acre and sulphate of potash at 50 lb. K_2O per acre, half before *kharif* sowing and half before *rabi* sowing.

I. Sulphate of ammonia at 40 lb. nitrogen per acre and superphosphate at 80 lb. P_2O_5 per acre, half before *kharif* sowing and half before *rabi* sowing.

J. Sulphate of ammonia at 40 lb. nitrogen per acre and sulphate of potash at 50 lb. K_2O per acre, half before *kharif* sowing and half before *rabi* sowing.

The results are :—

Mean yield per plot in lb.

Treatment	Maize P. F. 2	Oats B. S. II
A	17·790	11·352
B	21·458	21·721
C	25·505	22·435
D	20·116	15·209
E	18·208	15·197
F	18·602	14·415
G	16·770	10·279
H	21·911	22·534
I	21·902	23·485
J	21·166	15·092

In both cases Fisher's ' z ' test was applied and the results were significant at the one per cent. level. Fisher's ' t ' test was also applied for testing the mean differences between the treatments and the result was almost identical with both crops.

It was found with both crops that the treatments were divided into two distinct groups with significant difference between them but the differences between the treatments in each group were not significant. These groups are :—(1) Treatments B, C, H and I and (2) A, D, E, F, G and J.

(*iii*) *Green-manure and superphosphate experiments in the New Area, Waini Block.* The experiment was laid out in a Latin Square with five replications. The area of each plot was 1/10 acre ; oats B. S. I was grown in *rabi*.

Treatment per acre	Time of manuring	Mean yield of oats grain per plot in	' z ' test	' t ' test for mean difference
		lb.		
T. 1 Fallow	...	131·8	Not significant.	T. 2 > T. 1 and T. 5 > T. 1 at the 5% level of significance.
T. 2 Fallow and superphosphate @ 80 lb. P_2O_5.	Super applied at the break of monsoon.	162·0		
T. 3 Sann-hemp	..	134·6		
T. 4 Sann-hemp with superphosphate @ 80 lb. P_2O_5.	Super applied before sowing sann-hemp.	147·4		
T. 5 Sann-hemp with superphosphate @ 80 lb. P_2O_5.	Super applied before sowing oats.	162·8		

(*iv*) *Manurial experiments with sulphate of potash and muriate of potash on berseem seed production.* Berseem, one of the best fodder crops for milch cows in winter, is grown here from imported seed. Seed formation in berseem is very scanty in these parts though the plant flowers abundantly.

The experiment was started this year to see the possibility of bringing about seed formation by applying the following treatments :—

1. Sulphate of potash at 100 lb. per acre.
2. Sulphate of potash at 200 lb. per acre.
3. Muriate of potash at 100 lb. per acre.
4. Muriate of potash at 200 lb. per acre.

The experiment was laid down in two series—one received the above treatments in three doses while in the other series the treatments were applied in four doses.

The experiment is being continued.

(*v*) *Manurial experiments with superphosphate and oil-cake on sugarcane Co. 210 in the New Area, Block IV.* The lay-out of the experiment was a Latin Square with 4 replications and the area of each plot 1/18 acre. In all treatments, the total amount of super and half nitrogen were applied at planting and the other half of nitrogen in the middle of June. The P_2O_5 in the oil-cake was not deducted from the main dressing of super.

Treatment per acre	Sucrose % in juice (December)	Tonnage. Mean yield per plot in lb.	'z' test	't' test for mean difference
T. 1—75 lb. P_2O_5	16·66	1,924·50	Significant at the 5% level	T. 2 and T. 3 > T. 1 at the 1% level and T. 4 > T. 1 at the 5% level. There is no significant difference between T. 2, T. 3 and T. 4.
T. 2— Do. + 40 lb. N	15·54	2,324·50		
T. 3— Do. + 60 lb. N	16·04	2,413·25		
T. 4— Do. + 80 lb. N	15·27	2,315·50		

(*vi*) *Manurial experiments with superphosphate and oil-cake on sugarcane Co. 210 in the New Area, Block IV.* The experiment was laid out in a Latin Square with four replications and the area of each plot 1/18 acre. In all treatments, super and half nitrogen were applied at planting and the other half of nitrogen in the middle of June.

Treatment per acre	Sucrose % in juice (December)	Tonnage		
		Mean yield per plot in	'z' test	't' test for mean difference
		lb.		
T. 1—No manure	15·12	1,055·25	Significant at the 1% level.	T. 2, T. 3, T. 4 > T. 1 at the 1% level of significance. There is no significant difference between T. 2, T. 3 and T. 4.
T. 2—100 lb. P_2O_5 + 40 lb. N.	15·85	1,778·00		
T. 3—100 lb. P_2O_5 + 60 lb. N.	14·27	1,846·50		
T. 4—100 lb. P_2O_5 + 80 lb. N.	16·11	1,859·75		

(*vii*) *Manurial experiments with diammonphos and standard manure on sugarcane Co. 210 in the New Area. Bamboo Block.* The experiment was laid out in Beaven's half-drill-strip method with 11 replications ; the area of each plot was 1/40 acre. Half diammonphos was applied at planting and half at ridging ; standard manure, *viz.*, 50 lb. P_2O_5 *plus* 40 lb. N, was applied at planting.

Treatment per acre	Sucrose % in juice (February)	Tonnage			
		Mean difference	Standard error	Critical difference	Result
T. 1—200 lb. diammonphos.	16·42	13·09 lb. in favour of diammonphos	16·03	35·71 (P. = ·05)	Not significant.
T. 2—Standard manure (50 lb. P_2O_5 + 40 lb. N)	16·70				

(viii) Manurial experiments with oil-cake on sugarcane Co. 210 in the New Area, Bamboo Block. The treatments per acre were :—

(1) 80 lb. nitrogen in two doses.

(2) 80 lb. nitrogen in one dose.

The lay-out of the experiment was Beaven's half-drill-strip method with 11 replications and the area of each plot was 1/40 acre.

Treatment	Sucrose % in juice (February)	Tonnage			
		Mean difference	Standard error	Critical difference	Result
T. 1—N in 2 doses	15·94	82·27 lb. in favour of 2 doses.	23·87	75·64 (P. = ·01)	Highly significant.
T. 2—N in 1 dose.	16·02				

(ix) Manurial experiments with sulphate of ammonia and nitrate of soda on sugarcane Co. 210 in the New Area, Bamboo Block. The treatments per acre were :—

(1) 80 lb. nitrogen as $(NH_4)_2SO_4$: Half nitrogen was given at the break of the monsoon and the other half after one month.

(2) 80 lb. nitrogen as $N_a\ NO_3$: Half nitrogen was given at the break of the monsoon and the other half applied one month later.

The experiment was laid out in Beaven's half-drill-strip method with 15 replications ; the area of each plot was 1/40 acre.

Treatment	Sucrose % in juice (January)	Tonnage			
		Mean difference	Standard error	Critical difference	Result
T. 1—$(NH_4)_2SO_4$	15·09	20·20 lb. in favour of $NaNO_3$.	24·93	53·47 (P. = ·05)	Not significant.
T. 2—$NaNO_3$	15·07				

2. Varietal Yield Trials

(*i*) *Maize varietal trial for corn in North Pangarbi field.* The experiment was put in two separate Latin Squares ; a spacing of 18″ within rows was tried in the one and 15″ in the other lay-out. The distance between rows was kept at 2·5 feet in both cases. The area of each plot was 1/40 acre and the number of replications four.

Results of 18 inches spacing within rows

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
P. F. 1 . .	39·11	Not significant.	Differences between the varieties are not significant.
P. F. 2 . .	36·33		
P. F. 3 . . .	41·50		
Local . . .	36·67		

Results of 15 inches spacing within rows

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
P. F. 1 . .	45·68	Significant at the 5% level.	P. F. 3 > P. F. 1 and P. F. 2 at the 5% level.
P. F. 2 . .	44·15		
P. F. 3 . .	51·54		
Local . . .	46·12		

(*ii*) *Varietal trial with maize for fodder in North Pangarbi field.* This experiment was also put in two separate Latin Squares ; the two different spacings tried were (1) 15 inches and (2) 12 inches within rows ; the distance between rows was 2·5 feet in both squares. The size of plot and number of replications were the same as in the previous experiment.

Results of 15 inches spacing within rows

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
P. F. 1 . .	637·625	Not significant.	Not significant.
P. F. 2 . .	604·875		
P. F. 3 . .	592·500		
Local . . .	590·375		

Results of 12 inches spacing within rows

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
P. F. 1 . .	724·625	Not significant.	P. F. 1 > P. F. 2 and local at the 5% level.
P. F. 2 . . .	671·375		
P. F. 3 . .	697·500		
Local . . .	673·500		

(*iii*) *Varietal trial for seed with grain in North Pangarhi field.* This experiment was laid down in a Latin Square with 8 replications for each type. The area of a plot was 1/64 acre. The following are the results of the experiment :—

Types	Mean yield per plot in lb.	'z' test
T. 17	9·06	Significant at the 1% level.
T. 25	9·48	
T. 28	14·73	
T. 58	15·70	
P. F. 3	8·98	
P. F. 6	7·16	
P. F. 11	13·19	
P. F. 17	10·04	

't' test for mean differences :—

T. 58 > P. F. 17, T. 25, T. 17, P. F. 3 and P. F. 6
T. 28 > Do.
P. F. 11 > T. 25, T. 17, P. F. 3 and P. F. 6
at the 1 % level,
T. 58 > P. F. 17, T. 25, T. 17, P. F. 3 and P. F. 6
T. 28 > Do.
P. F. 11 > Do.
P. F. 17 > P. F. 6
at the 5 % level

and the differences between T. 58, T. 28 and P. F. 11 are not significant (at the 5 % level).

(*iv*) *Varietal trial with barley for grain in North Pangarbi field.* This experiment has been continued from 1930-31 ; the lay-out of the experiment this season was in Randomised Blocks. The plot area was 1/80 acre and number of replications eight.

The following are the results of the experiment :—

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
T. 21 . . .	26·36	Significant at the 1% level.	T. 21 > C. 251, L. I and L. II at the 1% level.
C. 251 . . .	22·27		
Local I . . .	20·92		
Local II . .	22·27		

3. Experiments for other Sections of the Institute

(*i*) *Manurial experiments on sugarcane Co. 213 for the Imperial Agricultural Chemist in Nawabi field.* The experiment was laid out in a Latin Square with four replications to see the effect of different treatments on tonnage and sucrose content of the cane. The treatments per acre were as follows :—

T. 1—100 lb. N as mustard cake.

T. 2—100 lb. N + 50 lb. K_2O as K_2SO_4.

T. 3—100 lb. N + 100 lb. P_2O_5 as superphosphate.

T. 4—100 lb. N + 50 lb. K_2O + 100 lb. P_2O_5.

The results of the experiment will be dealt with by the Imperial Agricultural Chemist.

(*ii*) *Green-manuring experiments for the Imperial Agricultural Bacteriologist.* The experiment carried out during 1931-32 was repeated this year also on the same plots. In addition to this another green-manuring experiment was started on a larger scale. There were five treatments with five replications laid down in a Latin Square. The size of plots was 1/5 acre each. The following treatments were tried : (1) fallow, (2) *urid* green-manured, (3) soybean green-manured, (4) sann-hemp green-manured and (5) sann-hemp tops buried and fibre extracted from the stems. The results of these two experiments have been incorporated in the report of the Imperial Agricultural Bacteriologist.

Ploughing at 5 miles and 2½ miles per hour on light land.

(*iii*) *Varietal trial with wheat for the Imperial Agricultural Bacteriologist : P. 52 against country wheat.* The experiment was continued this year in old Jhilli. It was laid out in Beaven's half-drill-strip method with 17 replications. The size of plot adopted was 1/12 acre. The following are the results of the experiment :—

Varieties	Mean difference	Standard error	Critical difference	Results
Pusa 52 . .	In favour of country wheat 4·45 lb.	2·92	6·18 (P. = ·05)	Not significant
Country . .				

(*iv*) *Tonnage experiment for the Imperial Mycologist with Co. 213 : mosaic* versus *mosaic-free cane.* The experiment was continued this year also in the silk house area ; the results of the experiment will be dealt with by the Imperial Mycologist.

4. Miscellaneous Experiments

(*i*) *Silage investigations.* Investigations with berseem silage were continued. Separate pits were filled with various mixtures on different dates and the wastage, moisture content and feeding value noted. The results have been written up in a separate note.

(*ii*) *Experiment to see the effect of speed of tractor-drawn implements on soil preparation and crop yields.* The experiment was laid down in Chhonia field in Beaven's half-drill-strip method with eleven replications for each treatment. Each strip measured 1,150 feet × 18 feet. Treatment No. 1 consisted of ploughing with a 5-furrow plough at seven inches on first speed at 2½ miles per hour and harrowing with Baron Tandem Disc Harrow on the same speed. The treatment No. 2 was ploughing with a 3-furrow plough at 7 inches on third speed at five miles per hour and harrowing with Roderic Lean Disc Harrow at the same speed. The "Vickers" tractor was used for the work.

The 5-furrow plough working at 2½ miles per hour left the furrows open and the furrow slice was not broken properly while the 3-furrow plough working at 5 miles per hour turned the furrows completely over, the furrow slice was pulverised thoroughly and the ploughed surface was smooth. The effect is clearly shown in the illustration given (Plate I). The time taken for ploughing was the same in both treatments.

Oats B. S. I was sown in *rabi* and the statistical results from its yield are given below proving that the higher speed does not affect tilth nor crop production :—

Treatment	Mean difference	Standard error	Critical difference	Results
T. 1—5-furrow plough at $2\frac{1}{2}$ miles speed. T. 2—3-furrow plough at 5 miles speed.	In favour of T. 2 = 9·59 lb.	12·435	27·705 (P. = ·05)	Not significant

(*iii*) *Spacing experiments with maize P. F. 2 for corn in North Pangarbi field.* The experiment was started to find out the most suitable spacing for maize within rows. Four different spacings—12, 15, 18 and 24 inches—were tried in a Latin Square with four replications ; the distance between rows was kept at 2·5 feet. The size of each plot was 1/40 acre.

The following are the results of the experiment :—

Treatment	Mean yield per plot in lb.	'z' test	't' test for mean difference
T. 1—12 inches .	48·06	Significant at the 1% level	T. 1 > T. 3 and T. 4
T. 2—15 inches .	42·50		T. 2 > T. 4
T. 3—18 inches .	38·68		T. 3 > T. 4 at the 1% level and also T. 1 > T. 2 at the 5% level
T. 4—24 inches .	29·82		

(*iv*) *Sugarcane cutting experiment at Meghaul, District Monghyr.* As the data obtained from the cutting experiment of Co. 205 conducted last year on an area of two acres in Harpur Jhilli was not sufficient for working out the optimum plot size for sugarcane experiments, the present cutting experiment was undertaken this year. An area of 4·5 acres of Co. 213, the standard cane in North India, was kindly given for this purpose by Mr. C. Atkins, Manager, Dowlatpur Agricultural Concern, and with his assistance the cutting

was completed. The whole area of 4·5 acres was cut into 1,088 plots—each consisting of a single row 3 feet wide and 60 feet in length. The results of the experiment will appear in a separate publication.

VII. SUGARCANE VARIETAL WORK

The tremendous impetus given to the sugar industry by the extensive grant of protection has brought work on cane into greater prominence than ever before. The enormous increase in cane cultivation caused by the almost universal drop in the prices of all other crops has brought to the front several other problems which until the year under report were not regarded as pressing. The great extension of the crushing season has made it clear that the industry needs not only an early cane but also a late one and at present a great deal of money is being wasted in purchasing cane which has gone back in quality through being unable to stand into April and May. At Pusa this need was foreseen and we are now in the third year of experiments with a cane of this type. Work on Co. 281, as a cane suitable for irrigated areas under factory control, has now reached an estate scale and some 12 acres have been planted under this cane for a large scale test which, it is hoped, will definitely show that an increased amount of sugar per acre over the standard variety now irrigated can be obtained in a normal crop.

The following varieties were planted on a field scale during 1932-33 :—Co.'s 210, 213, 214, 281, 285, 299, 300, 301, 302, 303, 304, 312, 313, 316, 317, 318, 319, 322, 326, 331, 335 and 337.

The following varieties were under multiplication in the nursery :—Co.'s 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349 and 350. Sorghum hybrids 351, 352, 353, 354, 355, 356 and 357.

The following varieties were under observation in the nursery :—Tuc. 393, Tuc. 472, P. O. J. 2878. Imported in 1932 :—Co.'s 381, 382, 384, 386, 387, 388, 393, 395, 396 and 397.

The following varieties were rejected in 1932-33 for 1933-34 planting :—Co.'s 300, 301, 302, 312, 316, 317, 318, 319, 326, 335, 340, 341, 342, 345, 346, 349, 351, 352, 353, 354, 355, 356, 357 and P. O. J. 2878.

The following varieties were planted during February 1933 :—

(*i*) *Field-scale trial* :—Under varietal tests—Co.'s 210, 213, 214, 281, 285, 299, 303, 304 (under observation), 313, 322, 331, 337, 339, 343 and 344.

(*ii*) *Small-scale trials* :—Under multiplication in the New Area nursery—

(*a*) Varieties imported from Coimbatore in 1930 :—Co.'s 347, 348, 350, 393, Tuc. 393 and Tuc. 472. (Co. 338 under observation at Sericulture area).

(*b*) Varieties imported from Coimbatore in 1932 :—Co.'s 381, 382, 384, 386, 387, 388, 393, 395, 396 and 397.

(*c*) Varieties imported from Coimbatore in 1933 :—Co.'s 360, 366, 367, 368, 369, 370, 371, 372, 373, 374, 375, 376, 377, 378, 379, 380, 381*, 382*, 383, 384*, 385, 386*, 387*, 388*, 389, 390, 391, 392, 393*, 394, 395*, 396*, 397*, 402†, 408†, 412†, 413†, 417† and 419†.

Sugarcane varietal test

In addition to the standard varieties we have now the following canes in reserve which have completed their tests and are being examined for minor points as to their suitability for various areas—Co. 299, Co. 313, Co. 331 and Co. 285. Co. 299 is practically as early as Co. 214 and far superior to it in tonnage as proved by the experiments conducted last year. Co. 313 is another promising early variety which has yet to obtain a clear certificate from mosaic before any further advance can be made towards distribution. Co. 331 represents the late cane required for April and May crushing. It is of high tonnage and can stand much longer in the field without deterioration than any other variety now grown on an extensive scale in the tract. Co. 285 represents the most suitable cane for water-logged areas but the distribution of this cane has now been suspended as ample supplies of Co. 210 and Co. 213 are available to the mills and the extension of cane growing to poor land is no longer required.

Another problem of great importance to cane growers is the question of the preservation of seed of *early* canes of the Co. 214 type in the field as great damage is done to the seed-cane crop by jackals and much damaged seed has to be planted. The trashing of such early canes for seed has been successfully accomplished and the entire experiment has been written up for publication separately. Further work on this line is now in progress. Co.'s 303 and 322 are liable to lodge badly but they have been retained for the present to see the effect of interlocking experiments with Co. 213 in preventing lodging.

Co.'s 337, 338, 343, 344 and 304 are still under observation.

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*Repeats. †Thick canes.

The analysis results of the above varieties of canes are given below :—

Serial No.	Sugarcane varieties	Sucrose per cent. in juice			
		October, 1932	November, 1932.	December, 1932	January, 1933
1	Co. 210 . .	..	15·43	15·58	15·71
2	Co. 213 . .	..	13·59	14·50	17·39
3	Co. 214 . .	14·27	13·49	17·68	17·42
4	Co. 281 . .	12·76	14·25	18·23	..
5	Co. 285 . .	..	14·66	14·55	16·51
6	Co. 299 . .	14·73	15·63	17·92	18·26
7	Co. 303 . .	..	11·10	14·91	16·70
8	Co. 304 . .	..	12·64	13·66	15·05
9	Co. 313 . .	12·71	17·23	18·13	17·87
10	Co. 322 . .	..	12·62	16·03	18·21
11	Co. 337 . .	..	14·30	16·92	18·00
12	Co. 338 . .	..	16·43	17·25	17·62
13	Co. 339 . .	..	13·61	14·74	17·15
14	Co. 343 . .	..	13·58	15·08	16·08
15	Co. 344 . .	..	15·48	16·55	16·50

Analysis of Co. 331 as a late ripening cane is given subsequently.

Rejection of sugarcane varieties

Co.'s 300, 301 and 302 were rejected as they failed to compete successfully with our early and mid-season standard varieties. Co. 312, which is one of the heaviest yielders, lodges very badly and is quite unable to stand in the field after September and has therefore to be discarded. Co. 316 was discarded for tonnage, while Co.'s 317, 318 and 319 which were of the Co. 285 type were found inferior to this cane and rejected. Co. 326 was very badly lodged and was of poor sucrose and tonnage. Co. 335 showed very poor growth and was of exceedingly low tonnage. Co.'s 340, 341, 342, 345, 346 and 349 were rejected on account of bad agricultural habit. Co. 351 to Co. 357, sorghum hybrids, were expected to ripen in six months' time from the date of planting, and to supply

the mill with canes at a time when normal canes were not available, thus reducing the overhead charges of the mill by enabling it to work throughout the year, but since these varieties have failed to fulfil this desired object, they were rejected as useless to the tract. P. O. J. 2878 has been finally discarded on account of stunted growth and bad agricultural habit.

Results of field experiments conducted with different sugarcane varieties

(*i*) *Varietal trial with sugarcane for tonnage in Phatak field.* The experiments were laid out in Beaven's half-drill-strip method with 15 replications ; the plot area was 1/24 acre each. The following are the results of the experiments :—

Varieties	Sucrose % in juice (January)	Tonnage			
		Mean difference	Standard error	Critical difference	Results
Co. 210 .	15·43	In favour of Co. 331 = 113·45 lb.	44·297	95·017 (P. = ·05)	Significant at the 5% level.
Co. 331 .	15·30				
Co. 210 .	15·56	In favour of Co. 213 = 34·83 lb.	43·32	92·92 (P. = ·05)	Not significant.
Co. 213 .	14·61				
	Sucrose % in cane (November)				
Co. 214 .	15·36	In favour of Co. 299 = 335·26 lb.	43·02	128·07 (P. = ·01).	Significant at the 1% level.
Co. 299 .	15·63				

Co. 331 is a cane of good agricultural habit but appears to be a late ripening variety as will be seen from the chemical analyses of juice carried out on different dates and therefore likely to be of value to the grower for late harvesting.

Date of analysis	Sucrose per cent. in juice	
	Co. 331	Co. 210
6th January 1933	15·30	15·43
17th February 1933	15·16	15·65
16th March 1933	17·78	15·19
16th March 1933	16·93	16·06
3rd April 1933	17·16	15·39
3rd April 1933	16·47	15·98
11th April 1933	17·49	17·68
11th April 1933	18·64	17·22
18th April 1933	18·36	13·50
18th April 1933	16·45	14·90
25th April 1933	17·67	14·31
25th April 1933	17·06	15·60
4th May 1933	18·53	14·91

From these analyses it would appear that Co. 331 is definitely able to stand on when Co. 210 has gone back completely and will pay to grow for late season crushing.

(*ii*) *Preliminary trial with new Co. cane varieties for tonnage in Phatak field.* The trial was conducted on the "chess-board" system with 16 replications for each variety. The plot area taken was 1/40 acre. The results of the experiment are given below :—

Varieties	Sucrose % in juice (December)	Tonnage		
		Mean yield per plot in lb.	'z' test	't' test for mean difference
Co. 300	14·73	994·09	Significant at the 1% level.	Co. 312 > Co.'s 300, 301, 302, 316 and Co. 301 > Co.'s 300, 302 and 316 at the 1% level.
Co. 301	13·69	1,228·03		
Co. 302	13·12	1,064·94		
Co. 312	11·08	1,456·50		
Co. 316	13·89	979·81		

(*iii*) *Varietal trial with sugarcane for tonnage in the New Area, Block IV.* The three standard varieties of cane Co.'s 210, 213 and 214 were tried with Co. 281 in a Latin Square with 4 replications. The plot area was 1/30 acre. The following are the results of the experiment :—

Varieties	Mean yield per plot in lb.	'z' test	't' test for mean difference
Co. 210 . .	1,179·50	Significant at the 5% level.	Co. 210 > Co. 281 at the 1% level and Co. 210 > Co. 213, Co. 281; Co. 214 > Co. 281 at the 5% level.
Co. 213 . .	850·25		
Co. 214 . .	996·00		
Co. 281 . .	752·50		

(*iv*) *Trashing of Co. 281 for seed.* The chief difficulty of growing Co. 281 or any other early ripening cane is the damage caused to the seed-cane by jackals and pigs when left standing in the field for seed after the harvesting of the main crop. The trashing of this cane for seed purpose was tried this year also in the New Area and Phatak with great success. The following are the variations in the chemical analyses of juice of trashed and fresh canes :—

Description	Date of analysis	Average weight of cane in lb.	Juice %	Sucrose %	Purity %
1. Co. 281 fresh .	21st Dec. 1932.	2·25	66·11	18·23	87·60
2. Co. 281 trashed on 20th Dec. 1932.	21st Jan. 1933.	1·30	61·50	15·40	79·18
3. Do. .	31st Jan. 1933.	1·43	70·93	19·01	82·40
4. Do. . .	31st Jan. 1933.	1·35	62·96	17·75	80·63
5. Co. 281 trashed on 10th Jan. 1933.	21st Jan. 1933.	2·10	64·29	18·12	85·88
6. Do. .	31st Jan. 1933.	1·93	65·52	18·36	82·18

It was found that the trashed canes suffer a loss of about 20 per cent. in weight in 55 days. Germination of trashed setts was one week later than the short-planted setts. Laboratory tests showed the germination percentage to be 61 per cent. for trashed and 98 per cent. for short-planted cane. Though the short-planted canes had a better start at the beginning, the deficiency was made up by the trashed canes after the break of rains in April and now there is practically no difference in growth between them.

VIII. MISCELLANEOUS CROPS GROWN FOR THE SECTIONAL OFFICERS OF THE INSTITUTE

(1) The following improved varieties of crops were grown for the Imperial Economic Botanist in the Agricultural Section for seed multiplication. The average yield of each variety per acre is given below :—

Serial No.	Field	Crops	Area in acre	Yield per acre in mds.	Remarks
1	Gonhri .	Wheat P. 4 .	10·00	13·05	Somewhat affected by frost.
		Wheat P. 12 .	9·00	16·25	Do.
		Wheat P. 52 .	10·00	15·99	Do.
		Barley T. 21 .	10·00	29·47	..
2	Jhilli .	Gram T. 25 .	5·00	9·56	..
		Gram T. 58 .	3·00	11·92	..
		Gram T. 17 .	4·00	8·83	..
3	Mysore .	New Hibiscus .	5·00	Partly cut for seed and fibre by B. S. and partly buried by Farm.	Sown broad cast.
		New Hibiscus .	5·00		Sown with drill.
		Arhar T. 80 .	9·50	1·63	Affected by frost.
4	Nepauli .	Lentil T. III-86	1·00	6·82	..
		Linseed T. 121.	1·00	4·32	..
		Linseed T. 124.	1·00	4·03	..
		Linseed T. 12 .	1·00	7·00	..
5	Punjab—D Block	Wheat P. 111 .	6·00	5·93	Greatly affected by frost.
6	Punjab—B Block	*Arhar* eight varieties.	8·00	5·28	Do.

(2) The following crops were grown in small plots for the study of insect pests by the Imperial Entomologist :—

Kharif—Soybean, maize, *til* (*Sesamum indicum*), sunflower, *mung* (*Phaseolus radiatus*), castor, *bajra* (*Pennisetum typhoideum*) and *juar* (*Andropogon Sorghum*).

Rabi—Sugarcane Co. 210, Co. 213, Co. 281 and Co. 285, peas, gram, wheat, linseed, chillies, tobacco, safflower, mustard and lentil.

IX. MACHINERY

(1) Steam ploughing tackle and tractors

The steam ploughing tackle was stood off almost completely during the year as a matter of economy. All main cultivation operations were done with tractors except the preliminary run by steam tackle before *rabi* preparations. The Marshall 15/30 H. P. fuel Diesel tractor which was purchased in March 1932 was given a full trial. Working costs and analysis of operations are given in the statement below as compared with the three other tractors worked during the year. The Lanz Bulldog tractor is in its third year, the International in its sixth year and the Vickers in its fourth year. To compare the Marshall tractor with the International, the first year's working details of the latter are also given :—

Cost per acre

Name of tractor	Ploughing	Disc harrowing	Grubbing
	Rs. a. p.	Rs. a. p.	Rs. a. p.
Marshall	1 12 9	0 14 0	0 13 3
International	2 12 0	1 6 5	1 7 2

These figures clearly show that with all points taken into consideration the crude oil principle in agricultural machinery of all kinds has definitely come to stay, and no tractor owner can afford, in these days of low prices for produce, to neglect the obvious method shown above for reducing costs.

The results of the year's working have shown that the crude oil tractor is as easy to start, manipulate and work as any kerosene oil tractor. De-coking which is required by these crude oil models after every 50 hours running is a very simple process, takes about six hours and can be done by any mistry after brief instructions.

The oil air cleaner and provision of cylinder liner in the Marshall tractor are distinct improvements over the Lanz Bulldog which has a dry air cleaner and no cylinder liner.

A report dealing with the actual comparisons of crude oil and kerosene oil tractors working will be published separately.

I. Statements showing the output, consumption and cost of cultivation by tractors for the year 1932-33

(a) Output

Serial No.	Name of tractor	Working hours	Summary of the work done									
			Ploughing		Disc harrowing		Grubbing		Rolling		Drilling	
			Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres
1	Marshall Fuel Diesel 15/30 H. P.	460·79	165·54	161·89	91·75	183·38	125·50	263·83	6·50	25·38	71·50	217·00
2	Lanz Bulldog semi Diesel 15/30 H. P.	316·50	97·75	80·15	54·75	105·50	96·00	192·50	68·00	248·50	..	..
3	McCormick Deering 15/30 H. P.; K. Oil.	104·25	50·50	50·82	37·75	83·08	16·00	40·46	..	..	..	..
4	Vickers 23/40 H. P.; K. Oil .	346·75	39·75	58·57	304·50	676·05	..	..	2·50	9·62	..	..

Serial No.	Name of tractor	Working hours	Acreage per hour				
			Ploughing	Disc harrowing	Grubbing	Rolling	Drilling
1	Marshall Fuel Diesel 15/30 H. P.	460·79	0·97	1·99	2·10	3·90	3·03
2	Lanz Bulldog semi Diesel 15/30 H. P.	316·50	0·82	1·92	2·00	3·65	..
3	McCormick Deering 15/30 H. P.; K. Oil.	104·25	1·00	2·20	2·52	..	..
4	Vickers 23/40 H. P.; K. Oil .	346·75	1·47	2·22	..	3·84	..

(*b*) *Consumption*

Name of tractor	Working hours	Fuel						Engine and Gear Oil		Grease	
		Crude Oil		K. Oil		Petrol					
		Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total lb.	Per hour lb.
Marshall Fuel Diesel 15/30 H. P.	460·79	714·40	1·53	17·11	0·03	..	..	89·60	0·19	79·00	0·17
Lanz Bulldog semi Diesel 15/30 H. P.	316·50	504·44	1·59	13·67	0·04	..	..	60·41	0·19	52·75	0·16
McCormick Deering 15/30 H. P.; K. Oil.	104·25	..	..	267·08	2·56	10·16	0·09	22·82	0·22	17·59	0·16
Vickers 23/40 H. P.; K. Oil	346·75	..	..	1,181·38	3·40	24·41	0·07	91·26	0·26	67·59	0·19

	Waste	
	Total lb.	Per hour lb.
Marshall Fuel Diesel 15/30 H. P.	32·37	0·07
Lanz Bulldog semi Diesel 15/30 H. P.	25·25	0·08
McCormick Deering 15/30 H. P.; K. Oil	17·01	0·16
Vickers 23/40 H. P.; K. Oil	31·49	0·09

(c) *Cost*

Serial No.	Name of tractor	Working hours	Analysis of total cost					
			Wages of the mistries and water carriers	Kerosene oil	Crude oil	Petrol	Lubricants	Spare parts and sundry stores
			Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
1	Marshall Fuel Diesel 15/30 H. P.	460·79	103 4 11	11 7 9	354 9 1	..	266 11 8	10 5 0
2	Lanz Bulldog semi Diesel 15/30 H. P.	316·50	44 11 2	9 1 9	248 4 6	..	175 15 11	23 13 5
3	McCormick Deering 15/30 H. P.; K. Oil.	104·25	16 0 4	176 7 0	..	16 6 9	52 0 7	203 8 0
4	Vickers 23/40 H. P.; Kerosene oil.	346·75	63 4 0	787 5 3	..	39 2 10	238 13 3	914 8 4

	Analysis of total cost		
	Repairing staff and miscellaneous wages	Total	Expenses per hour
	Rs. a. p.	Rs. a. p.	Rs. a. p.
1. Marshall Fuel Diesel 15/30 H. P.	67 3 1	813 9 6	1 12 2
2. Lanz Bulldog semi Diesel 15/30 H. P.	93 6 4	803 5 1	2 8 5
3. McCormick Deering 15/30 H. P.; K. oil	40 1 0	504 7 8	4 13 5
4. Vickers 23/40 H. P.; kerosene oil	165 14 1	2,208 15 9	6 5 11

(d) Cost per acre

Serial No.	Name of tractor	Ploughing	Disc harrowing	Grubbing	Rolling	Drilling
		Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
1	Marshall Fuel Diesel 15/30 H. P.	1 12 9	0 14 0	0 13 3	0 7 2	0 9 3
2	Lanz Bulldog semi Diesel 15/30 H. P. . . .	3 1 5	1 5 0	1 4 1	0 11 0	..
3	McCormick Deering 15/30 H. P.; kerosene oil .	4 13 5	2 3 2	1 14 6	..	..
4	Vickers 23/40 H. P.; kerosene oil	4 5 1	2 13 11	..	1 10 4	..

II. Statement showing the consumption and expenses of the tractors for belt pulley work for the year 1932-33

Name of tractor	Working hours	K. oil		Petrol		Crude oil		Lubricating oil	
		Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total gallons	Per hour gallons
McCormick Deering	128·25	265·80	2·072	10·00	0·077	..	..	29·96	0·233
Cost	..	Rs. a. p. 176 2 9	..	Rs. a. p. 16 2 0	..	..	..	Rs. a. p. 61 9 2	..
Vickers	68·75	171·61	2·496	6·50	0·094	..	..	17·665	0·256
Cost	..	Rs. a. p. 112 9 9	..	Rs. a. p. 10 9 0	..	..	..	Rs. a. p. 37 13 1	..

	Grease		Waste	
	Total lb.	Per hour lb.	Total lb.	Per hour lb.
McCormick Deering	24·00	0·187	7·12	0·055
Cost	Rs. a. p. 4 15 4	..	Rs. a. p. 0 14 11	..
Vickers	15·00	0·218	5·87	0·085
Cost	Rs. a. p. 2 13 0	..	Rs. a. p. 0 11 9	..

Name of tractor	Working hours	Spare parts and sundry stores	Wages of the mistries and water carriers	Repairing staff and miscellaneous wages	Total expenses	Expenses for running per hour
		Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.
McCormick Deering	128·25	250 7 5	22 3 2	49 4 0	581 10 9	4 8 6
Vickers	68·75	181 4 8	12 13 10	32 15 0	391 10 1	5 11 1

III. Working details of the McCormick Deering tractor during 1927-28 (the 1st year of working)

Working hours	Ploughing per hour	Disc harrowing	Grubbing	K. oil consumed per hour	Cost of spare parts	Expenses per hour
	Acre	Acre	Acre	gallons	Rs. a. p.	Rs. a. p.
291·30	0·87	1·71	1·65	1·61	13 15 7	2 6 5

Cost per acre		
Ploughing	Disc horrowing	Grubbing
Rs. a. p.	Rs. a. p.	Rs. a. p.
2 12 0	1 6 5	1 7 2

NOTE.—In the first year we had no four-furrow ploughs and a three-furrow plough was used.

2. Thresher

Investigations dealing with the design of a small thresher suitable for Indian conditions at a price within the range of small land-owners were concluded. The new thresher fitted with a completely redesigned type of drum was given an exhaustive test and proved itself in every way suitable. The daily output is given below :—

Date	Time	Yield	Yield per hour
	Hours	Mds.	Mds.
25th March 1933 . . .	3·250	14·481	4·455
26th March 1933 . . .	3·283	17·178	5·232
27th March 1933 . . .	2·716	12·745	4·692
28th March 1933 . . .	4·166	15·993	3·839
29th March 1933 . . .	3·800	16·937	4·457
30th March 1933 . . .	4·016	11·525	2·869
31st March 1933 . . .	2·650	8·450	3·188
1st April 1933	2·883	7·550	2·618
2nd April 1933 . . .	3·366	11·479	3·410
3rd April 1933 . . .	3·700	11·807	3·191
5th April 1933 . . .	2·815	9·035	3·209
6th April 1933 . . .	4·330	18·575	4·286
7th April 1933 . . .	4·350	16·850	3·873
9th April 1933 . . .	3·566	22·443	6·293
10th April 1933 . . .	4·416	22·225	5·032
11th April 1933 . . .	4·283	21·587	5·040
	57·590	238·860	..

Average per hour :—4·15 maunds.

The entire experiment has been written up for publication separately.

The design for a standard bullock gear to work the above thresher was remodelled and further tests are in progress. It is hoped to bring out the entire outfit at a price within Indian limits.

X. CATTLE BREEDING

The pedigree Sahiwal herd stood at 227 head during the year under report. The remainder of the cross-bred stock with three exceptions were disposed of (Appendix—Table I).

It is of considerable interest to note that the quarter-bred stock ($\frac{3}{4}$ Sahiwal and $\frac{1}{4}$ Ayrshire) sired by bull Cello No. 23, the stud bull of this herd in 1919, has proved of very high milking quality ; one cow now at Hosur having given 13,083 lb. to-date (500 days) in her second lactation and one cow now in the third lactation at Pusa giving 32 lb. per day from three quarters at 83 days.

This line of work appeared very promising as the stock is good all round and appears little affected by disease or climatic conditions, and its cessation is regretted.

Table II in the Appendix shows the total yield of milk from the herd and the method of its disposal during the year under report. Owing to the disposal of the remainder of the cross-breds, the herd produced 54,297 lb. less milk. This decrease in the total milk yield had its effect on the production of cream, *ghee* (clarified butter) and skim milk.

During the season, the local price of milk was reduced very considerably and this affected the sale of this product from the dairy—a large number of our Indian customers preferring an impure article at a cheaper rate, as a result less milk was sold from the herd.

The special calf feeding experiments in relation to early maturity account for the large increase in the amount fed to calves. Rations for bad doers and weak animals in the herd account for the increased issue of milk for medicinal purposes.

The most noticeable point regarding the Pusa Sahiwal herd during the year under report has been the increase in the milk yield of the herd. The new system of feeding and handling referred to in the last report was worked throughout the year and the yield of the herd per cow per day was raised from 13·6 to 17·9 lb. and the percentage of cows in milk increased from 50·2 to 55·1 (Appendix—Table III).

The first year's results of this experiment have been written up and will be published. Briefly recapitulated, they are : (*i*) increase in the total milk yield of the herd by 47 per cent., (*ii*) a reduction in the cost per lb. of milk, (*iii*) a reduction in the amount of concentrates fed, (*iv*) no increase in the general expenses of the herd, (*v*) a reduction in the service period ; (*vi*) a steady rise in weight after milking condition had been reached ; and (*vii*) a steady maintenance of the average fat percentage of 4·7 in the milk yield throughout.

During the year under report, the herd milch record, which had stood for ten years, was beaten by five cows, while the heifer record was passed by two heifers—the highest lactation being 8,863 lb. in 304 days for cows, and 7,648 lb. in 304 days for heifers, the herd record being 7,053 lb. in 305 days previously (Appendix—Table IV).

In order to get some line of comparison with other pedigree herds which do not adhere rigidly to the 304 days' lactation period, as practised in this herd, Sahiwal cow Chengi No. 534 was allowed to pass over the fixed period and has done 9,746 lb. to date in 447 days and is giving 12 lb. daily.

Despite the general drop in the price of cattle throughout India no difficulty was experienced in disposing of surplus stock at good prices. The demand for good pedigree stock is still very great and the herd has a waiting list of orders for cows and stud bulls at high prices.

Calf rearing. During the year under report the special system for obtaining early maturity with pail-fed calves was carried on. Marked gains in body weight and more rapid maturity were observed, while the calf mortality figures are given below and show the effect on the general health of the pail-fed calves for the period of the experiment (Appendix—Table V).

XI. PROGRAMME OF WORK FOR 1933-34

1. Cultivation investigations with special reference to production of tilth and condition of soil associated with speed of implements.

2. Green-manuring investigations with special reference to water requirements in various soils and conditions required by different crops.

3. General treatment of a 600-acre farm with special reference to reduction of costs in cultivation and the rotations suitable to the introduction of machinery.

4. Line-breeding investigations with a pedigree herd of Sahiwal cattle with special reference to the transmission of milch characters.

5. Experiments on feeding and digestion trials in collaboration with the Physiological Chemist to determine the digestive capacity of Indian cattle.

6. Special feeding of young calves with a view to early maturity to lengthen the profit period of the average Sahiwal cows and the bulls.

7. Investigation of the threshing problem in India and the design of a small threshing plant to suit all-India requirements.

PUSA SAHIWAL HERD.

Five Best Milkers 1933.

Laruli 604	Lalagi 596	Ramati 566	Chandrika 482	Ajbi 567
7648 lb.	7019 lb.	8863 lb.	8081 lb.	8060 lb.
1st lact.	1st lact.	2nd lact.	4th lact.	2nd lact.

PLATE II.

8. Experiments with various types of motor tractors and general tractor implements for collection of data and determination of most suitable types of tractors and implements for Indian conditions.

Collaboration with manufacturers with regard to the manufacture and test of new types of implements built to correlate with present tractor design.

9. Investigations on silage problems.

10. Experimental work—

(*a*) The design, lay-out and general technique connected with modern field experiments.

(*b*) Trials of new varieties of crops.

(*c*) Manurial experiments.

(*d*) Trials of sugarcane varieties suitable for growth without irrigation for various classes of soils and with ripening dates corresponding to the alteration in factory conditions.

(*e*) Rotational experiments.

(*f*) Crop experiments in collaboration with Sectional Officers.

11. Training of post-graduate students.

12. Touring and advisory.

XII. PUBLICATION

Sayer, M. Wynne.....Soybean (*Glycine hispida* Maxim.). *Agri. and Live-stock in India*, III, 5 (September, 1933).

APPENDIX

TABLE I

Annual statement of live-stock as it stood on the 30th June, 1933

Serial No.	Breed	Description of cattle	No. of animals from last year as it stood on 1st July 1932	Increase			Decrease			Disposed of otherwise	Total
				By birth	By transfer	By purchase	By death	By transfer	By sale		
1	Sahiwal cattle	Bull	8	..	6	..	..	..	4	..	10
2	Do.	Cow	81	..	24	..	1	..	16	8	80
3	Do.	Young male stock	53	49	..	..	5	4	31	2	60
4	Do.	Young female stock	59	35	..	..	1	24	..	2	67
5	Progeny of Sahiwal cows and Ayrshire bull.	Bull	..	..	..	..	..	..	..	..	..
6	Do.	Cow	15	..	..	..	..	..	13	..	2
7	Do.	Young male stock	..	..	..	..	..	..	..	..	..

8	Do.	Young female stock	..	..	..	..	..	..	..	..	
9	Miscellaneous crosses	Bull	..	..	..	..	..	..	..	..	
10	Do.	Cow	1	..	..	..	..	..	..	..	1
11	Do.	Young male stock	15	1	..	..	..	..	7	8	1
12	Do.	Young female stock	10	1	..	..	..	..	10	..	1
13	Cart bullocks	..	5	..	..	..	..	..	..	..	5
		Total	247	86	30	..	7	28	81	20	227
1	Sheep	Male stock	25	19	..	..	5	..	16	..	23
2	Do.	Female stock	46	14	..	..	5	..	..	..	55
		Total	71	33	..	..	10	..	16	..	78

TABLE II

Statement showing total milk yield and its disposal for 1932-33

Month.	Total milk yield	Disposal								Cream				Ghee		Skim-milk				
		Sold	Issued for				Thrown or split	Shortage	Total	Quantity obtained	Sold	Converted into ghee	Shortage	Sold	Otherwise disposed	Quantity obtained	Sold	Fed to calves	Fed to cattle	Misc. disposal
			Medicine	Analysis	Cream	Calves														
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	oz.	oz.	oz.	oz.	oz.	oz.	lb.	lb.	lb.	lb.	lb.
1932.																				
July	27,124	14,441	5	39	6,834	5,679½	39	86½	27,124	7,925	447	7,475	3	3,908	..	6,144	277	3,043	2,828	1
August	27,841	14,241½	171½	37½	7,427	5,853	72	38½	27,841	8,622	546	8,076	..	6,960	..	6,590	256	2,443	3,888	3
September	26,590	13,663	324½	39½	6,833	5,603½	46	80½	26,590	7,771	487	7,262	22	7,466	88	6,098	311	2,582	3,201	4
October	24,788	10,977	372	21	5,707	7,627½	10	70½	24,788	6,630	655	5,966	9	7,344	56	5,078	458	1,934	2,682	4
November	22,555	10,990½	776	39½	3,352	7,295	26	76	22,555	3,682	714	2,957	11	5,360	40	2,968	341	1,418	1,200	9
December	22,112	10,208½	969	35	4,550	6,259	8	82½	22,112	5,216	795	4,417	4	858	16	4,046	355	1,800	1,890	1
1933.																				
January	19,770	9,757½	827½	43	1,831	7,166½	13½	131	19,770	1,983	1,091	884	8	3,116	160	1,591	296	678	614	3
February	17,438	8,467	635	27	1,243	6,928	11	127	17,438	1,378	685	683	10	164	..	1,038	256	656	125	1
March	21,707	10,413½	696	33	1,559	8,909½	11	85	21,707	1,726	559	1,152	15	492	..	1,328	359	869	86	14
April	23,987	10,889	497	33	2,288	10,204	4½	71½	23,987	2,489	649	1,821	19	152	..	2,006	461	1,092	437	16
May	32,599	11,477	508	42½	9,995	10,515	5	56½	32,599	11,047	569	10,477	1	574	..	8,991	419	3,846	4,722	4
June	33,479	11,525½	240	48	9,337	12,229	17	82½	33,479	10,091	1,061	9,028	2	2,214	..	8,473	495	3,149	4,827	2
Total	299,990	137,051	6,021½	441	60,956	94,269½	263	988	299,990	68,560	8,258	60,198	104	38,842	360	54,351	4,279	23,510	26,500	62
Total for 1931-32.	354,287	180,006½	134	158	89,776	82,831½	204	1,177	3,54,287	1,01,191	10,753	90,304	134	32,300	44	80,504	3,434½	32,091	44,964	14½

Table III

Statement of milk yield of Sahiwal cows for 1932-33

Month	Sahiwal cows						Percentage in milk
	Yield	Average yield per day	Average yield per cow per day	No. of cowsin milk and dry			
				Total No.	In milk	Dry	
July 1932	21,992	709	17·7	81	40	41	49·4
August	24,198	781	18·6	82	42	40	51·2
September	23,755	792	18·0	82	44	38	53·7
October	23,295	751	17·1	75	44	31	58·7
November	21,379	713	16·6	75	43	32	57·3
December	20,785	670	17·6	70	38	32	54·3
January 1933	18,802	607	17·3	68	35	33	51·5
February	16,973	606	17·8	74	34	40	45·9
March	21,543	695	17·8	78	39	39	50·0
April	23,480	783	17·8	78	44	34	56·4
May	30,730	991	19·1	80	52	28	65·0
June	31,110	1,037	19·2	80	54	26	67·5
Average per month	23,170	761	17·9	77	42	35	55·1
Average for 1931-32	16,617	515	13·6	79	40	39	50·2

TABLE IV

Milk record for the Sahiwal herd and heifers, 1932-33

Name of cows and heifers		Best lactation in lb.	Days	Previous best lactation in lb.	Days
Cows—	1. Ramati	8,863	304	5,066	306
	2. Chandrika	8,081	305	5,465	304
	3. Ajbi	8,060	306	4,014	303
	4. Chengi*	7,901	304	6,681	304
	5. Mukta	7,254	306	5,536	304
	6. Makhi	7,226	306	5,478	303
	7. Lakhni	7,017	304	5,582	305
Heifers—	8. Laruli	7,648	304	..	..
	9. Lalagi	7,019	306	..	..
	10. Bansuri	5,034	306	..	..

*She has done 9,746 lb. to-date (447 days) and is giving 12 lb. at present.

NOTE :—Previous herd record :—Kamli 7,053 lb. in 306 days (1926).
Previous heifer record :—Kamli 5,785 lb. in 304 days (1921).

TABLE V

Sahiwal calf mortality figures

(Pail-fed period)

Period	No. of calves	Mortality per cent.
April 1931, to March 1932	70	4·3
April 1932, to March 1933	69	1·4

REPORT OF THE IMPERIAL ECONOMIC BOTANIST

(F. J. F. Shaw, D.Sc., A.R.C.S., F.L.S., I.A.S.)

(1) BOTANICAL SECTION, PUSA

I. ADMINISTRATION

Dr. Shaw held charge of the Section throughout the year under report. Mr. Kashi Ram continued to officiate as Assistant Economic Botanist. The post of Special Research Assistant was sanctioned for another year and Mr. R. D. Bose continued to hold it. The post of Second Economic Botanist remained vacant.

A sum of about Rs. 1,573 was realized mostly from the sale of improved seeds. Most of the work of multiplying and distributing seed of improved types of crops was carried out on the Pusa Farm in collaboration with the Imperial Agriculturist.

Training

Three students completed their post-graduate training in this Section in October 1932. All three rendered material help in the different problems to which they were attached.

Mr. S. Majid, B.Sc., continued to receive his training during the year under report and six students joined the post-graduate course in November 1932.

In the first week of March all the students of this Section were sent to the Botanical Sub-station at Karnal for about a week to study the growth of crops under the irrigation conditions which are typical of northern India.

Three students from the Agricultural Section were permitted to attend the course of lectures delivered in this Section in genetics, biometry and statistical methods as applied to field trials.

A special course of training in the flue-curing of tobacco was instituted this year and although there were a number of applicants for this, for want of accommodation only seven students could be admitted to this course. In selecting students preference was given to officers of the Agricultural Departments in India. The course extended from the 2nd January, 1933, to the 15th February, 1933.

A dairy student from the Institute of Animal Husbandry Bangalore, was also given a short training in this Section.

Season and Rainfall

The most notable feature of the season was the incidence of a severe frost in January 1933, a phenomenon which had not occurred in Bihar for about 30 years. Delicate crops like tobacco and chillies were the worst affected, and were almost completely killed. These crops suffered more on dry light soils deficient in moisture than on clayey and moisture-retaining lands. Plots of tobacco and chillies that had been irrigated in the Botanical Section, for instance, escaped severe damage, while plots which were not so treated were affected seriously.

The total annual rainfall remained below the average for the last 25 years (1906—1930) by 8·71 inches. The rainfall in the *kharif* season was well distributed, but was 33 per cent. less than the average of 25 years ending 1930. The major portion of the shortage was in July and August, the middle period of the season. Consequently the *kharif* crops, specially rice and maize, suffered on account of deficiency of rain. For the sowings of *rabi* crops, however, the rainfall was quite sufficient in November, but was a little late for some crops like peas, *sarson*, etc.

Statement of rain in the Botanical Section in 1932-33

Month	Average for 25 years (1906—30)	From 1st June 1932 to 31st May 1933	Difference
	Inches	Inches	Inches
June 1932	7·53	7·01	—0·52
July	11·08	6·04	—5·04
August	14·09	7·12	—6·97
September	8·05	7·54	—0·51
October	1·81	0·60	—1·21
November	0·43	2·71	+2·28
December	0·18	0·30	+0·12
January 1933	0·34	0·03	—0·31
February	0·68	0·59	—0·09
March	0·41	0·00	—0·41
April	0·56	1·36	+0·80
May	1·44	4·59	+3·15
Total	46·60	37·89	—8·71

Statement showing the seed distribution in 1932-33 of improved crops evolved in the Botanical Section, Pusa

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	Total
		lb.	lb.	lb.
Barley	Type 1	23	..	23
	„ 2	2	..	2
	„ 21	3,309	4,526	7,835
Chilli	„ 34	4 oz.	..	4 oz.
	„ 41	3 oz.	..	3 oz.
	„ 51	4 oz.	..	4 oz.
Gram	„ 2	50	..	50
	„ 6	1	..	1
	„ 17	469	1,414	1,883
	„ 25	230	443	673
	„ 28	63	..	63
	„ 58	258	716	974
	„ 51	217	..	217
Linseed	„ 12	1,168	638	1,806
	„ 121	652	346	998
	„ 124	279	329	608
	Hybrid 2	1	..	1
	„ 10	20	..	20
	„ 11	1	..	1
	„ 13	1	..	1
	„ 21	16	..	16
	„ 55	72	..	72
	„ 63	1	..	1
	„ 68	16	..	16
Lentil	Type 2	2	..	2
	„ 11	51	..	51

Crop	Variety	By the Botanical ection, Pus	By the Pusa Farm	Total
		lb.	lb.	lb.
	Type III-54 . . .	2	..	2
	,, III-86 . . .	101	535	636
Mung . .	,, 23 . . .	1	..	1
	,, 28 . . .	2	..	2
	,, 34 . . .	2	..	2
	,, 36 . . .	1/2	..	1/2
	,, 53 . . .	1/2	..	1/2
Oats . .	B. S. 1	880	4,155	5,035
	B. S. 2	337	1,008	1,345
	Hybrid A . . .	18	..	18
	,, B . . .	12	..	12
	,, C . . .	906	..	906
	,, D . . .	12	..	12
	,, E . . .	12	..	12
	,, F . . .	53	..	53
	,, G . . .	12	..	12
	,, H . . .	42	..	42
	,, I . . .	12	..	12
	,, J . . .	349	..	349
	,, K . . .	12	..	12
	K. S. 10 . . .	6	..	6
Patwa . .	Type 3	50	..	50
	,, 6	94	..	94
	New Type . . .	88	..	88
Paddy . .	Culture 66 (A) . .	26	..	26
	,, 490 . . .	25	..	25
	,, 753 . . .	25	..	25
	,, 836 . . .	25	..	25
	,, 850 . .	25	..	25

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	Total
		lb.	lb.	l.
Rahar	Type 15	87	..	87
	„ 16	169	20	189
	„ 5	1	..	1
	„ 24	627	..	627
	„ 41	41	..	41
	„ 50	330	..	330
	„ 51	351	..	351
	„ 64	227	..	227
	„ 69	89	82	171
	„ 80	177	..	177
	„ 82	229	..	229
Safflower	„ 30	16	..	16
Sesamum	„ 7	27	..	27
	„ 29	101	..	101
Tobacco	„ 28	15	..	15
	Hybrid 177	9	..	9
	Type 18	1/2	..	1/2
Urid	„ 7	1/2	..	1/2
	„ 14	1	..	1
	„ 15	2	..	2
	„ 17	1/2	..	1/2
	„ 22	1/2	..	1/2
	„ 23	2	..	2
Wheat	Pusa 4	264	2,206	2,470
	Pusa 12	956	1,603	2,559
	Pusa 52	755	7,859	8,614
	Pusa 80—5	968	206	1,174

Crop	Variety	By the Botanical Section, Pusa	By the Pusa Farm	Total
		lb.	lb.	lb.
	Pusa 101 . . .	1,765	..	1,765
	Pusa 111 . . .	832	503	1,335
	Pusa 112 . . .	4	..	4
	Pusa 114 . . .	101	..	101
	Pusa 115 . . .	82	..	82
	Pusa 120 . . .	10	..	10
	Pusa 165 . . .	10	.	10

II. INVESTIGATIONS

Wheat (*Triticum vulgare* Host.)

The year under report was one of average yields and bushel weights compared favourably with the average of previous years. This may be seen from the following table :—

Wheat	Weight per bushel in lb.		
	Average of 6 years ending 1930-31	1931-32	1932-33
Pusa 4	63·50	66·1	66·3
„ 12	61·35	65·0	64·3
„ 52	63·94	66·8	66·4
„ 101	..	66·8	67·1
„ 111	..	66·2	66·1
„ 114	..	66·7	64·2

Frost damaged the early wheats, preventing the formation of grain in those varieties which were coming into ear at the time of the frost. This was well illustrated by the coefficient of correlation between length of ear and number of grains per ear in

the year under report. This biometrical constant has been calculated for the three chief Pusa wheats for the past eight years, and in the early wheat Pusa 4 in the past season a much lower value for the coefficient of correlation was realized than in the preceding years. The results are described in detail in a paper submitted for publication.

A regular system for maintaining the purity of the seed supply of the established Pusa wheats has been established in the Botanical Section. Seed is taken from typical single plants of each type every year and in the succeeding year is sown in five rows. Seed from the five rows is sown in a small plot in the next year and from this plot sufficient seed is obtained to sow one acre in the following year. From this, seed is given in the next season for sowing on ten-acre plots in the Agricultural Section on the Pusa Farm. The crop on the Farm is therefore only four generations removed from a single plant, and this seed is available for distribution to different departments of agriculture and others.

Outside India also Pusa wheats are gaining a reputation for yield and quality. Thus in Rhodesia (*Rhodesia Agr. Jour.*, Volume XXX, January 1933) a prize for the best bag of seed wheat was won with Pusa 4. The Director of Plant Breeding, New South Wales, reports—" We have had several Pusa wheats from time to time from India and of these Pusa 4 is now grown fairly extensively in New South Wales, being amongst the twenty leading varieties in this State. Pusa 12 appears to be resistant to flag smut and may be of a value as a parent in breeding. Pusa 111 has so far only been tested on a small scale but it is promising in comparison with Pusa 4. Pusa 113 is a promising wheat with good quality grain and so far it has been more productive than Pusa 4 in small tests. Pusa 114 may prove of value in our dry districts but is very susceptible to stem rust."

The wheat-breeding work with the hybrids between Federation and Pusa 4 and Federation and Pusa 52 has now reached the stage at which yield trials are being conducted with the more promising hybrids. Two trials were laid down in Latin Squares in the year under review—the incidence of frost has however seriously affected the significance of the results. One of the hybrids (No. 1054) has been tested in the U. S. A. and found resistant to five physiological forms of *Puccinia triticina*.

Barley (*Hordeum vulgare* L.)

The demand for the seed of Type 21 barley now far exceeds the supply, and the popularity of this type as a high yielding variety necessitates that larger areas of this be cropped in future. During the year under review only 3,309 lb. could be supplied

from the Botanical Section and 4,526 lb. from the Pusa Farm. The Deputy Director of Agriculture, Muzaffarpur, in addition, has been making large-scale distributions of this type.

At the Sepaya Agricultural Farm in North Bihar an average yield of 1,868 lb. per acre was obtained this year from an area of 8·5 acres, and in varietal trials conducted there Pusa Type 21 beat both Pusa Type 23 and local barley significantly by 9·6 per cent. and 31 per cent. respectively. The Gungowli Concern in North Bihar reports that this type of barley has averaged 35 maunds (2,870 lb.) per acre during this year. The Superintendent, Muzaffarnagar Farm, United Provinces, obtained the following yields in a trial conducted by him this year :—

Muzaffarnagar trial

Type	Average yields in lb. per acre
Pusa Type 21	3,290·5
Cawnpur barley	2,714·0
Local barley	2,863·0

Trials conducted during the year under the directions of Economic Botanist to Government, Cawnpur (In charge of barley and cotton investigations), gave the results shown below :—

Cawnpur trial

Type	Average yields in lb. per acre
Pusa Type 21	3,115·4
Cawnpur Type 251	2,489·0
Cawnpur Type 255	2,737·0

Raya Farm trial

Type	Average yields in lb. per acre
Pusa type 21	3,678·8
Cawnpur type 251.	3,826·0
Local barley	4,107·6

At the Government Farm, Etawah, a yield of 3,004·4 lb. has been obtained from Pusa barley Type 21 this year from an area of 0·80 acre, giving an average of 3,755·6 lb. per acre. The Farm Superintendent reports that this type is better than Cawnpur 255, that its stand was excellent, and that the type would be tried again next year.

A sample of Pusa barley Type 7, which has invariably proved to be a poor yielder under Pusa conditions but which possesses a xerophytic type of root-system adapted to the soils of dry tracts, was sent to Rawalpindi in the Punjab for trial against some of the Punjab barleys, to determine its suitability for that tract, but the report of the Manager of the Agricultural Station shows that there too this type has failed to do well.

The early maturing hulless types of barley appeared to be damaged by frost to a considerably greater extent than the hulled types. Differential response to frost effect was also shown by various F_2 families growing under identical conditions in one and the same field. Whereas families from crosses in which both the parents were hulled showed hardly any damage, most of the families which had a hulless barley (Pusa Type 24) as one of the parents exhibited deformity of the ear-head and an indifferent amount of seed setting as an effect of frost.

A number of barley crosses in F_2 and F_3 generations were studied during the year and some very desirable types appear to have been evolved and will receive further attention in the future

The investigation regarding the resistance of all the 24 different types of Pusa barleys to *Helminthosporium* and the efficacy of certain seed disinfectants to control the disease has been continued with the collaboration of Dr. Mitra. Details of the results obtained will be found in the report of the Imperial Mycologist.

Some Pusa barleys have lately been used by the Geneticist of the Department of Agriculture, Victoria, Australia, who reports that the five Pusa types tried by him (*viz.*, Pusa barley Types 7, 12, 20, 21 and 24) mature from 7 to 14 days in advance of Pryor, the standard Australian variety, and, on this account, are of definite value for breeding purposes. He also reports that of more than 100 importations from numerous countries, these Pusa types are the most promising for use as parent material. Types 12 and 20 have been mated with Pryor and Plumage Archer for the production of early malting varieties, and with Cape for early feed. In addition, Type 24 will be used by him for the production of an early feed type suited to the drier areas of the State. A number of F_2, F_3 and F_4 cross-breds, the progeny of these matings, are undergoing field trials, and contain some very promising material. These reports of the success of Pusa barleys outside India are very encouraging.

Oats (*Avena sterilis* L.)

A paper on the improvement of the oat crop by selection and the acclimatization of exotic types has been sent in for publication. This paper embodies details regarding the isolation and cultivation of B. S. 1 and B. S. 2 oats and also gives an account of the attempted acclimatization of a number of exotic oats at Pusa. Invariably all European and American types of oats yield a profuse quantity of fine straw but they are all much too late to set a normal amount of seed under Indian conditions.

The inheritance of some characters in crosses between Scotch Potato and Pusa oats as well as between Abundance and a Pusa type formed the subject of a second paper sent in for publication. Both the Scotch Potato and the Abundance oats belong to the species *A. sativa* L. and all the Pusa oats belong to the species *A. sterilis* L. variety *culta*, but no difficulty was experienced in obtaining fertile hybrids from these inter-specific crosses. A number of very promising hybrids have been fixed from this material. It may be noted that single factor differences have been observed between *sativa* and *sterilis* types of base, *strong* and *weak* awns, and *long* and *short* basal hairs.

Two factors appear to be responsible on the other hand for the inheritance of amount of basal hairs, hairs on the margin of leaves.

Transgressive segregation indicating the presence of multiple factors has been observed in the inheritance of height of plants in all the three crosses studied, number of days taken to head out, and the number of spikelets per panicle in Crosses I and II (Scotch Potato × B. S. 4 and Scotch Potato × B. S. 2). While in Cross III (Abundance × B. S. 4) dominance of early maturing plants and of plants with a low spikelet number has been observed.

Yield trials with twelve hybrids and B. S. 1 and B. S. 2 oats, as outlined in the last year's annual report, were again conducted both at Pusa and at Karnal and have yielded promising and interesting results. They will be repeated for the third time in the ensuing season before any definite conclusions can be drawn. The response of different types to variations in soil and climate will, it is hoped, be elucidated by these trials.

The Assistant Director of Agriculture, Sepaya, conducted a varietal trial this year with two Pusa oats B. S. 1 and Hybrid C and found that under his conditions the former was significantly superior to the latter by about 30 per cent. in yield of grain. The yield of B. S. 1 in this experiment came to an average of 34·8 maunds (2,854 lb.) per acre.

A comparison of B. S. 1 and Pusa Hybrids C, F, and J against local farm oats was made this year at the Raya Agricultural Farm by the United Provinces Department of Agriculture and the following result has been reported :—

Name of variety	Area sown in acres	Actual outturn of green fodder in lb.	Outturn per acre of green fodder in lb.
Hybrid C	0·2	6,892	34,460
Hybrid F	0·2	4,276	21,380
Hybrid J	0·2	6,068	30,340
B. S. 1	0·2	5,535	27,675
Farm Seed (Raya) . . .	0·2	5,705	28,525

Hybrid C has been reported to yield the maximum quantity of green fodder but is rather early in maturity for Raya conditions.

Paddy (*Oryza sativa* L.)

The isolation of 135 types of Bihar paddies is practically completed, but their study during the year under review was hindered by the lack of rain and its bad distribution. The work will be completed during the current year.

Gram (*Cicer arietinum* L.)

The results of the cross between a Kabuli (Pusa Type 2) and a *desi* (Pusa Type 18) gram are now complete and have been written up for publication. The characters studied include flower colour, seed shape and seed colour. A scheme of factorial analysis for these characters and a genetical explanation of their inheritance has been devised.

Yield trials between some of the new types (48, 49, 51, and 58) and the old established Type 17 were carried out both at Pusa and at Karnal. In both cases Type 58 proved decisively superior to all the other types including Type 17. These two results, in combination with last year's result, suggest that in Type 58 we have definitely obtained a gram superior in yielding power to the older established varieties. Trials with Type 58 will be continued at Pusa and at Karnal next year and are also being organized in collaboration with provincial departments of agriculture in Sind, Punjab and United Provinces.

In a second yield trial at Pusa with Types 53, 54, 55 and 67 against Type 17 the former were all superior to Type 17. Further repetitions of this trial will be necessary to place the results on a significant basis.

Pigeon-pea (*Cajanus indicus* Spreng).

This crop suffered badly from frost almost everywhere except in the Botanical Section where the conservation of soil moisture appears to have been sufficient to enable the crop to withstand the frost to a considerable degree.

A yield trial with a number of the most promising types was carried out and four types, *viz.*, Types 15, 24, 51 and 64, all proved significantly better than local seed. Type 51 is erect in habit and

possesses a large yellow-brown seed, and is also wilt-resistant. These characters together with its high yielding capacity should make this type of great economic importance. At the Government Farm, Etawah, United Provinces, this type was grown on 1·50 acres of land this year and gave an average outturn of 2,228·5 lb. per acre. The Farm Superintendent reports that it was very little affected by frost in the month of January, while local *arhar* in adjoining cultivators' fields was badly affected.

Work on the inheritance of wilt-resistance was continued during the year under review.

A large F_2 population from the cross Type 80 (resistant) × Type 5 (susceptible) and its reciprocal was grown in two fields which were artificially infected with the disease, and also in a field which was not infected. The inheritance of flower colour was studied in relation to the disease and it was found that segregation was on a 9 : 3 : 3 : 1 ratio and that the ratio was not significantly disturbed in the population in the infected fields by the incidence of the disease. This means that the property of resistance to wilt disease is inherited independently of colour in the flower. The other characters studied, seed colour, stature and habit, all exhibited the same independence of disease-resistance, and we conclude therefore that the factors for disease-resistance are not linked with the factors which are concerned with the inheritance of any of these characters. This confirms the conclusions drawn from a previous experiment when an F_2 population was grown in an infected field.

The cross was first made some five years ago and the work during the past season was done to confirm the previous results. From the original cross the succeeding hybrid generations have been grown every year both under infected and non-infected conditions. In 1931-32 when the cross was in the F_4 generation it was noticed that some morphologically identical phenotypes were growing both in the population which together with all the preceding generations had been reared in non-infected fields and in the population of which all preceding generations had been grown under artificially infected conditions. The latter possessed a considerable degree of resistance to wilt, otherwise they would never have survived. Five phenotypes were selected from among these resistant hybrids in F_4 and five morphologically similar phenotypes were selected from among the hybrids (also in F_4) which had been reared under non-infected conditions. All the ten cultures were grown in an infected field in the year under review and it was found that four of the five hybrids reared under selection by the disease were strongly resistant, whereas the same phenotypes which had been reared out of contact with the disease proved heavily susceptible. This shows that the same morphological phenotype may be either resistant or susceptible.

A test for wilt-resistance of five types, with seven replications against Type 5, the control, gave the following results. :—

Type	Average percentage of deaths
5	84·93
16	6·12
41	0·72
51	8·88
80	0·82
82	1·07

The difference in wilt-resistance between Type 5 and the other types is statistically significant below the one per cent. level.

Peas (*Pisum sativum* L. and *P. arvense* L.)

The study of the types was continued and a yield trial with five types, grown without support, was carried out.

Lentils (*Ervum lens* L.)

A preliminary varietal trial with eight hybrid types of lentils against two selections was run this year, and it was found that some of the hybrid types out-yielded the selections and showed great promise. Regular yield trials with these will be taken up during the next season.

The study of inheritance of some characters in this crop has been completed and the results will be written up for publication.

Urid and Mung (*Phaseolus Mungo* L. *and P. radiatus* L.)

Two definite types of root-systems, *viz.*, mesophytic and xerophytic systems, were found in the Pusa types of green and black grams. Types coming from the alluvial soils of Bengal and Bihar invariably had mesophytic roots, whereas types which originated from seed collected from drier localities of the United Provinces, Punjab, North-West Frontier Province, and Peninsular India as well as most of the types from Burma all possessed a xerophytic type of root-system. The maximum depth of the main tap root was greater in the xerophytic than in the mesophytic types of both *mung* and *urid*, but *urid* generally had a distinctly deeper root penetration than *mung*. All early maturing types had a shallow working depth of their roots while all late maturing types had a deeper working depth. The lateral spread of secondary

roots was observed to be much greater in the mesophytic than in the xerophytic types of root-systems. A paper on the subject was submitted during the year under review.

Sann-hemp (*Crotalaria juncea* L.)

Owing to the failure of seed setting in this crop a large number of promising cultures from original samples received from different parts of India had to be rejected. Selections have been made and will be continued for some time in order to evolve one or more good types by mass selection.

Indian hemp (*Cannabis sativa* L.)

This is a dioecious crop in which natural cross-fertilization and wind pollination is the common rule. In the preparation of the narcotic, *ganja*, all the male plants are invariably weeded out before any pollination can take place. This is an important consideration in maintaining the purity of a type which may be evolved by mass selection. A number of selections have therefore been made from the *ganja* usually cultivated in Bihar which appears to be a mixture of very variable types. It is proposed therefore to continue the work on the selection and fixing of a good type of *ganja*.

The following sex ratios were observed this year in the different types of hemp studied :—

	Number of		Ratio of	
	♂ Plants	♀ Plants	♂ Plants	♀ Plants
Pusa H-17	16 :	20	1 :	1·25
Pusa Type 1	170 :	378	1 :	2·22
Pusa Type 2	102 :	215	1 :	2·11
B. and O. type (sample obtained from Hur-ingpur)	174 :	288	1 :	1·65

It is evident, of course, that the higher the proportion of female plants present in this crop, the higher is the yield of the final product (*ganja*) obtained and the less the amount of labour which has to be expended in weeding out male plants.

Tobacco (*Nicotiana tabacum* L.)

Work was continued on the inheritance of characters in a cross between white and pink flowered types. The progress of investigation in curing and yield in the crop was seriously hampered by the damage due to frost.

Chillies (*Capsicum annuum* L. and *C. frutescens* L.)

The original types were maintained and the work of isolating unit species in Goa chillies was continued. The results of the study of the inheritance of characters were published and the cross (Type 3 × Type 29) is regularly maintained in the Section for instructional purposes. New crosses to elucidate the inheritance of anther colour were made.

Hemp (*Hibiscus cannabinus* L. and *H. Sabdariffa* L.)

The study of the inheritance of characters in the crosses with *H. sabdariffa* var. *altissima* was continued and the results of the F_3 generation confirmed the conclusions drawn from the F_2 generation in the previous season.

An investigation on the variability of a Mendelian ratio in relation to the life-cycle of the parent was commenced with these crosses as they are well adapted to this study.

Linseed (*Linum usitatissimum* L.)

Testing of the ninety hybrids obtained from crosses, the results of which have already been published, was continued. Two hybrids, H. 55 and H. 21, were found to be equal to the standard Type12 in yielding power and to possess considerably higher oil percentage. Both these hybrids have the "white" seed colour which is more popular with the trade than the dark. Further tests with these and other hybrids will be continued.

Some types of linseed from Australia were grown, and it is possible that a use may be found for them as parents in crosses with Indian linseed. The Australian types possess large flowers but their oil-content in the past season was low. Further work on these types is needed; at present they appear to be mostly too late in maturity for Indian conditions.

The crosses with Type 15 described in the last annual report were continued to the F_3 generation and the theory of the inheritance of petal colour, which was previously described, was confirmed.

The F_3 generations of the crosses Type 15 × Type 4, Type 15 × Type 21, and Type 15 × Type 24, were grown and studied. The F_2 results of segregations for petal colour in the first on tri-hybrid, in the second on monohybrid and in the last on dihybrid ratios were confirmed.

The F_2 generations of the following crosses were also grown and studied—Type 15 × Type 12, Type 15 × Type 20, Type 15 × Type 22, Type 1 × Type 24, and Type 4 × Type 24. In the cross Type 15 × Type 12, the segregation for petal colour character was on a 9 : 3 : 3 : 1 ratio. The cross Type 15 × Type 20 gave an indication of a dihybrid segregation for petal colour but due to difficulties in diagnosing different phenotypes decision as to the precise nature of the segregations in this cross must remain in abeyance. The results of Type 15 × Type 22 were similar to those of Type 15 × Type 21 studied last year where in F_1 the white petal was apparently dominant to blue and in F_2 a ratio of 3 whites : 1 blue was obtained. In the crosses Type 1 × Type 24 and Type 4 × Type 24 a ratio of 9 blue like F_1 : 3 blue like Type 24 parent : 4 white like the other parent was obtained for petal colour.

The results of these crosses have thrown light on the genetic constitution of most of the types and particularly of Type 15 which has hitherto been obscure.

The mean oil-content of 112 varieties and the maximum in any variety were respectively 39·03 and 42·78 per cent. Thus there is a decrease of 3·72 per cent. in the former and of 4·64 per cent.. in the latter compared with the last year's (1931-32) figures The minimum oil-content, however, shows an increase of 0·17 per cent. over last year's figures.

Statement showing the oil percentage of some high yielding linseed hybrids and the standard types from 1928-29 to 1932-33 (5 years)

Variety	Oil percentage					
	1928-29	1929-30	1930-31	1931-32	1932-33	Mean
Type 12	36·67	36·93	37·68	37·29	37·74	37·26
Type 121	40·01	40·13	38·88	41·50	39·80	40·06
Type 124	38·22	39·86	37·44	42·30	39·07	39·38
Hybrid 10 (T. 12 × T. 1)	43·00	42·20	41·49	45·50	41·90	42·82
Hybrid 21 (T. 12 × T. 8)	41·80	39·74	37·66	42·20	38·88	40·05
Hybrid 55 (T. 8 × T. 121)	44·03	40·26	42·23	44·73	42·78	42·81
Hybrid 68 (T. 22 × T. 121)	43·16	40·50	40·91	43·94	39·58	41·62

Safflower (*Carthamus tinctorius* L.)

The thirty-four types were maintained. The seeds of the variegated segregates from the variegated plant in Type 27 observed for the first time in 1929-30 which segregated into normal and variegated plants in the following year having failed to germinate last year the original stock of Type 27 seed was grown. A number of variegated plants were again observed out of which about a dozen were selfed for further study.

A few types have been crossed *inter se* with a view to study inheritance in this crop. The percentage of success was small but it shows that the types are crossable. Because of the thorny nature of plants and the aggregation of small, delicate flowers in a compact head the operations of emasculation and pollination were rendered very difficult.

Sesamum (*Sesamum indicum* D. C.)

Preliminary tests indicate that Types 3, 7 and 29 will be good yielders. The study of the inheritance of characters in this crop was continued. The economic object of this work is the production of a heavy-yielding white-seeded hybrid. White seed is a desirable character in this crop as such types yield a lighter coloured oil.

Brassica

The tentative classification of the types in the three self-fertile species, *viz.*, (1) Yellow *sarson* (*B. campestris* var. *sarson* Prain); (2) *Rai* (*B. juncea* Hooker); (3) Chinese mustard (*B. rugosa* var. *cuneifolia*, Prain) was checked and revised. Herbarium specimens of all the self-fertile and self-sterile groups of Brassica were prepared and sent to the Royal Botanic Gardens, Kew (England), for identification and confirmation of our classification of these groups.

The F_2 generations of the crosses between yellow *sarson*, a self-fertile group, and black *sarson* and Burma *sarson* belonging to the self-sterile groups were studied at Pusa to elucidate the inheritance of self-fertility and of seed characters. These crosses were :—

(1) Yellow *sarson* × Black *sarson* late (*B. campestris* var. *oleifera* Prain) and its reciprocal.

(2) Yellow *sarson* × Burma *sarson* (*B. oleracea* var. *chinensis* Prain) and its reciprocal.

Similar crosses between yellow *sarson* and *toria* (*B. napus* L. var. *dichotoma* Prain); and between yellow *sarson* and black *sarson* early (*B. campestris* sub-sp. *napus* var. *dichotoma* Duthie and

Fuller) were studied at the Botanical Sub-station, Karnal. The consideration of the mode of inheritance is made difficult by the fact that the self-sterile groups cannot be pure for the different characters. Some definite idea about the scheme of inheritance will be got next year from the study of the F_3 generations of the crosses. At present it appears that self-fertility is dominant over self sterility, and that red seed colour of *toria* or *sarson* is dominant over yellow seed colour of the yellow *sarson*.

The study of these crosses further shows that it is possible to secure a self-fertile plant with red seed, thus explaining the nature of the natural crosses that were found to be self-fertile and having red seed. It is therefore now possible to produce a desirable high yielding strain of red-seeded, self-fertile *sarson* or *toria*.

The *inter se* crosses between turnip and other Brassica group that were made at Pusa last year were studied at the Botanical Sub-station, Karnal, in their F_1 generation, and the results are stated in the report of that station.

Preliminary observations were made as regards the influence of cloudy weather on seed-setting and these will be repeated next year before any conclusion is drawn. Some strains of the self-sterile groups were grown at isolated places in order to make them pure multiple strains.

Taramira (*Eruca sativa* L.)

The sterility experiment was continued and some results will be available next year.

Statement showing the yield of crops in the Botanical Section in 1932-33

Crop	Plot	Outturn of grain in lb.			Remarks
		Area in acres	Actual	Per acre	
Wheat—					
Pusa 4 .	Western Orchard border D.	0·09	137	1,522	
„ 4 .	Orchard 4A part .	1·00	1,013	1,013	
„ 12 .	Pentagonal field part	1·05	1,826	1,739	
„ 52 .	Orchard 4A part .	1·03	1,205	1,170	
„ 80—5	Pentagonal field part	1·06	1,386	1,308	

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Wheat—contd.					
Pusa 80—5	Pentagonal west border.	0·13	180	1,385	
,, 101	,, field part .	1·06	1,952	1,842	
,, 111	,, ,, ,, .	1·05	1,328	1,265	
,, 111	,, east border	0·11	170	1,545	
,, 4 .	N. T. G. 1 part .	0·06	148	2,466	
,, 12 .	N. T. G. 1 part .	0·06	139	2,317	
,, 52 .	N. T. G. 1 part .	0·06	139	2,317	
,, 80—5	N. T. G. 1 part .	0·06	133	2,217	
,, 101	N. T. G. 1 part .	0·06	162	2,700	
,, 111	N. T. G. 1 part .	0·06	125	2,083	
,, 114	N. T. G. 1 part .	0·06	119	1,983	
Hybrid A	Orchard 6A part .	0·036	45	1,250	
,, B	,, .	0·036	37	1,028	
,, D	,, .	0·036	49	1,361	
,, E	,, .	0·036	44	1,222	
,, F	,, .	0·036	41	1,139	
,, G	,, .	0·036	36	1,000	
Pusa 52 .	,, .	0·036	67	1,861	
,, 4 .	,, .	0·036	42	1,167	
Hybrid K	,, .	0·036	45	1,250	
,, L	,, .	0·036	45	1,250	
,, M	,, .	0·036	27	750	
,, R	,, .	0·036	47	1,306	
,, N	,, .	0·036	45	1,250	
,, J	,, .	0·036	58	1,611	
,, O	,, .	0·036	26	722	

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Wheat—concld.					
Pusa 52 .	Orchard 6A part	0·036	56	1,556	
,, 52 .	Orchard 1A part	0·153	208	1,359	
Local .	,,	0·153	196	1,281	
Sesamum—					
Type 1 .	N. T. G. 10 part	0·14	54	386	
,, 7 .	,,	0·07	31	443	
,, 9 .	,,	0·07	19	271	
,, 15 .	,,	0·035	11	314	
,, 23 .	,,	0·035	9	257	
,, 28 .	,,	0·07	29	414	
,, 29 .	,,	0·14	73	521	
Tobacco—					
Type 63 .	Orchard 3A and B part.	0·54	471	872 Leaf	The crop was badly damaged by frost.
,, 58 .	,, ,,	0·55	348	633 ,,	
Hybrid 142	Inside Musahar	1·60	1,152	720 ,,	
,, 177	,,	0·40	236	590 ,,	
Cash .	,,	0·60	416	693 ,,	
Gram—					
Type 17 .	Riverside east, eastern half.	0·38	510·4	1,343·2	
,, 25 .	N. T. G. 4 .	0·33	469·4	1,422·4	
,, 28 .	Barah 1 part .	0·10	120·9	1,209·0	
,, 41 .	,,	0·02	41·0	2,050·0	
,, 58 .	Riverside east, western half.	0·38	701·1	1,845·0	
,, 17 .	Barah 1 . .	0·073	163·3	2,237·0	
,, 48 .	,, . .	0·073	170·4	2,334·2	
,, 49 .	,, . .	0·073	157·0	2,150·7	

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Gram— contd.					
Type 51	Barah 1	0·073	187·2	2,564·4	
,, 58	,,	0·073	203·0	2,780·8	
,, 17	,,	0·073	140·1	1,919·2	
,, 53	,,	0·073	183·75	2,517·1	
,, 54	,,	0·073	176·6	2,419·2	
,, 55	,,	0·073	156·4	2,142·5	
,, 67	,,	0·073	177·9	2,438·1	
Rahar—					
Type 15	Orchard 4B	0·109	235·8	2,163·3	
,, 16	,,	0·109	161·5	1,481·7	
,, 24	,,	0·109	210·25	1,928·9	
,, 41	,,	0·109	158·9	1,457·8	
,, 51	,,	0·109	218·9	2,008·1	
,, 64	,,	0·109	207·4	1,903·0	
,, 69	,,	0·109	192·6	1,767·0	
,, 80A2	,,	0·109	163·2	1,497·2	
,, 80A4	,,	0·109	166·25	1,525·2	
,, 82	,,	0·109	185·7	1,703·7	
Local	,,	0·109	188·4	1,728·6	
Type 24	Lawn plot 3	0·34	660·0	1,941·2	
,, 50	S. T. G. 6	0·20	403·8	2,019·0	
,, 51	S. T. G. 9	0·24	555·6	2,315·0	
Peas—					
A. 14	N. T. G. 9 part	0·06	30·75	512·5	Damaged more than other types by frost.
S. 14-1	,,	0·16	104·5	653·1	Damaged to some extent by rats.

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Peas—contd.					
S. 35 .	N.T.G. 9 part. .	0·05	66·6	1,332·0	
S. 36 .	,, . . .	0·05	53·3	1,066·0	
S. 14-1 .	N. T. G. 2 . .	0·036	45·4	1,261·1	
S. 35 .	,, . . .	0·036	34·4	955·6	
S. 36 .	,, . . .	0·036	35·7	991·7	
A. 14 .	,, . . .	0·036	10·75	298·6	
Farm No. 1	,, . . .	0·036	33·3	925·0	
Barley—					
Type 21 .	W. River bank .	0·74	2,683	3,626	
,, 21 .	Orchard 2D . .	0·71	1,254	1,766	Poor and heterogeneous plot. Barley put in after removal of fruit orchard.
,, 21 .	Orchard 5A part .	0·40	486	1,217	Sown very late after harvesting *urid*.
Local .	,, .	0·22	244	1,109	Ditto.
Oats—					
B. S. 1 .	S. Barah border .	0·35	820	2,343	
B. S. 1 .	Outside Musahar 4	0·20	490	2,450	
B. S. 2 .	,, ,, 2	0·20	363	1,815	
Hybrid F	,, ,, 3	0·20	316	1,580	
,, C .	,, ,, 1A part.	0·50	1,189	2,378	After taking a cutting of green leaves for fodder.
,, J .	,, ,, .	0·50	1,090	2,180	Ditto.
,, J .	N. T. G 5 part .	0·10	197	1,970	
,, A .	,, .	0·05	74·50	1,490	
,, B .	,, .	0·05	64·75	1,295	
,, C .	,, .	0·05	130·0	2,600	

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33—*contd.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Oats—contd.					
Hybrid D.	N. T. G. 5 part .	0·05	99·25	1,985	
,, E	,, .	0·05	101·75	2,035	
,, F	,, .	0·05	119·75	2,395	
,, H	,, .	0·05	74·50	1,490	
,, I	,, .	0·05	118·25	2,365	
,, J	,, .	0·05	124·50	2,490	
,, K	,, .	0·05	81·75	1,635	
B. S. 1 .	,, .	0·05	115·25	2,305	
B. S. 2 .	,, .	0·05	126·0	2,520	
Lentil—					
Type 11 .	S. T. G. 8 part .	0·15	148	987	
Hybrid III-86.	,, .	0·15	141	940	
Type 11 .	S. T. G. 3 part .	0·01	10·00	1,000	
,, 47 .	,, .	0·01	19·25	1,925	
Hybrid A	,, .	0·01	21·75	2,175	
,, B	,, .	0·01	20·50	2,050	
,, C	,, .	0·01	18·75	1,875	
,, D	,, .	0·01	16·25	1,625	
,, E	,, .	0·01	16·50	1,650	
,, F	,, .	0·01	19·25	1,925	
,, G	,, .	0·01	18·00	1,800	
,, H	,, .	0·01	16·75	1,675	
Linseed—					
Type 12 .	Orchard 6B . .	0·1	154	1,540	
Hybrid 10	,, .	0·1	146	1,460	
,, 13	,, .	0·1	129	1,290	

STATEMENT SHOWING THE YIELD OF CROPS IN THE BOTANICAL SECTION IN 1932-33—*concld.*

Crop	Plot	Area in acres	Outturn of grain in lb.		Remarks
			Actual	Per acre	
Linseed—contd.					
Hybrid 21	Orchard 6B .	0·1	149	1,490	
,, 23	,, .	0·1	119	1,190	
,, 38	,, .	0·1	131	1,310	
,, 55	,, .	0·1	151	1,510	
,, 68	,, .	0·1	137	1,370	
Safflower—					
Type 30 .	S. T. G. 7 . .	0·05	43	860	
Hibiscus—					
Type 3 .	Musahar Out No. 1.	0·30	69	230	
,, 3 .	South Orchard border.	0·09	24	266	
,, 6 .	Musahar Out No. 5.	0·28	120	428·5	
Chillies—					
(Semi dry) .	Barah 3 . .	0·85	438	515·33	Crop badly damaged by frost.

III. PUBLICATIONS AND PROGRAMME OF WORK FOR 1933-34

PUBLICATIONS

Deshpande, R. B.—Studies in Indian Chillies No. 3. The inheritance of some characters in *Capsicum annuum* L. *Indian Jour. Agri. Sci.* 3, 1933, 219-300.

Bose, R. D.—Application of modern statistical methods to field trials. *Agri. and Livestock in India*, 1933.

..... *and Jogleker, R. G.*—Studies in Indian Pulses No. 6. The root-systems of green and black grams. *Indian Jour. Agri. Sci.* 1933.

Shaw, F. J. F. and Bose, R. D.—Studies in Indian Oats I. The improvement of the crop by selection and the acclimatization of exotic types. *Indian Jour. Agri. Sci.* 1933.

. . . . . —Studies in Indian Oats II. Inheritance of some characters in interspecific crosses between *Avena sativa* L. and *A. sterilis* L. *var. culta. Indian Jour. Agri. Sci.* 1933.

Shaw, F. J. F.—Wheat and Barley in India (written for the World's Grain Exhibition and Conference, Canada, 1933).

Programme of work for 1933-34.

Investigations will be continued on the genetics of those crops which have formed the subject of this report. Special attention will be given to yield trials and statistical methods. Training of students will continue as in past years.

(2) Botanical Sub-Station, Karnal

(Financed by the Imperial Council of Agricultural Research)

I. INTRODUCTION

Khan Saheb Abdur Rahman Khan held charge of the Station throughout the year.

The post of Farm Assistant was filled up by the appointment of Mr. R. B. Ekbote (L. Ag. Honours) who joined his duties at Karnal on the 20th February 1933.

Training

All the post-graduate students of the Botanical Section, Pusa, visited the station in February 1933 and studied the following experiments :—

(1) Trials of two new hybrid wheats 120 and 165, which were too late for Pusa.

(2) Trials of Pusa barleys, wheats, etc., under irrigation. The reactian of the barleys and some varieties of wheat to rust under irrigated conditions was most striking.

(3) Yield trials of oats under irrigation.

(4) Yield trials of gram.

(5) Brassica types and cultures.

(6) F_2 and F_3 populations of gram crosses.

Season and Rainfall

The year 1932-33 was on the whole satisfactory. The outturn of gram was exceptionally very high. Yields of wheat varieties were also a little better than those of last year.

Rainfall during 1932-33

Month	Inches
June, 1932	1·02
July	8·72
August	6·53
September	10·30
October	0·02
November	..
December	2·06
January, 1933	0·09
February	1·02
March	0·90
April	0·61
May	1·92
Total	33·19

Machinery

The 'Bulldog Lanz' crude oil tractor continued to work satisfactorily both in running the 'Consul' thresher and cultivating the land. The plough 'Consul (3B)' did not prove very suitable for irrigated stiff lands of the station. It makes land very uneven which is not desirable for irrigated lands. The 'S-ft. Baron' disc-harrow proved to be very useful both for cultivating the land before sowing and covering the seed when sown broadcast. The 'Consul' thresher did very good work in threshing wheat, barley and oats. This year it was adjusted so that the percentage of broken grains in wheat was negligible, *i.e.*, less than 1 per cent. Grams can also be threshed in this machine but the percentage of broken grains comes to at the least 6 per cent.

II. INVESTIGATIONS

Paddy

Out of the 76 samples collected from different places in the Punjab and other parts of India, 125 different types have been isolated. Among these 10 types are very promising and are being grown on large observation plots for comparison. A tentative classification of all the isolated types has been made which will shortly be sent for publication.

Wheat

One of the objects of starting the Karnal Sub-Station was to provide an area in which late maturing varieties bred at Pusa might be tried under conditions which are more favourable for their development than are available in Bihar. A good deal of work has been done in this direction and two new hybrid wheats, 20-1 and 3-1, have given very good results at Karnal. Having proved successful in the preliminary tests permanent numbers P. 120 and P. 165 respectively have been given to them. Tests will be made simultaneously at Pusa, at Karnal and at several farms in the Punjab and the United Provinces under various climatic and other conditions including canal irrigated, well irrigated and *barani* (rain-fed) lands.

The varieties to be tried at Karnal will be as follows :—P. 120, P. 165, P. 4, P. 12, Punjab 8A, and two other varieties selected by the Punjab Agricultural Department.

Two crosses of wheat were made in 1930 at Pusa and were taken to Karnal for study. The F_2 generation of these crosses was studied during the current year.

(1) P. 52 × P. 111.

P. 111 × P. 52.

(2) P. 111 × 6-1-4-1 (P. 52 × Fed.)

6-1-4-1 (P. 52 × Fed.) × P. 111.

The parents P. 52 and 6-1-4-1 (P. 52 × Fed.) are fully bearded, while P. 111 is beardless. The F_1 plants of all the crosses were short-tipped. In F_2 the following segregation took place.

Name of the cross	Beardless	Short tipped	Long tipped	Very long tipped	Half bearded	Fully bearded	Total
1. P. 52 × P. 111	62	376	155	112	41	37	783
P. 111 × P. 52.	47	343	162	135	36	73	796
Total	109	719	317	247	77	110	1,579
2. 6-1-4-1 (P. 52 × Fed.) × P 111	41	384	143	121	42	56	787
P. 111 × 6-1-4-1 (P. 52 × Fed.)	49	487	201	130	59	62	988
Total	90	871	344	251	101	118	1,775

It will be seen that the fully bearded and beardless classes are each 1/16th of the total population indicating a two factor segregation.

	Beardless	Fully bearded	Total population
Cross No. 1			
Observed	109	110	1,579
Expected	98·7	98·7	
Cross No. 2			
Observed	90	118	1,775
Expected	110·9	110·9	

All promising fully bearded plants have been selected for growing next year and it is hoped to obtain a bearded variety with the grain qualities of P. 111.

Many unfixed hybrid cultures of wheat originally sent from Pusa were grown and selection work was continued. The following five cultures of Canadian wheats were also grown :—

(1) Garnet Ottawa beardless.
(2) ,, ,, half bearded.
(3) ,, ,, tipped.
(4) Reward Ottawa short-tipped.
(5) ,, ,, long-tipped.

All were late in maturity and produced shrivelled grains. They are more susceptible to black rust and are not suitable for growing in the Punjab. However they possess very good standing power and can be used as parents in crosses.

Some Japanese wheats were also tried but were badly attacked by black rust and gave very poor results.

The incidence of bunt (*Tilletia indica*) in wheat was severe in the year under report and was investigated by the Assistant Mycologist, Pusa. The disease was most severe in P. 112 and P. 113, was less severe in P. 111, P. 80-5 and P. 120 and was least in P.'s 4, 12, 52, 114 and 165. All seed will be treated before next sowing.

A statement showing the outturn of different types of wheat grown on a large scale is appended.

Gram.

All the 84 types of gram were maintained.

A yield trial experiment in randomized blocks was carried out with the following four varieties with 10 replications :—T. 58, T. 17, T. 28, Local. Type 58 gave the best results with a yield of 3,021 lb. per acre, local was second with a yield of 2,702 lb. per acre but its grain colour is not popular, T. 17 was third with a yield of 2,507 lb. per acre and T. 28 the last, its yield being 1,949 lb. The results were tested statistically by the analysis of variance and it was shown that the superiority of T. 58 was statistically significant at the one per cent. level. This result agrees with the results of two other yield trials conducted at Pusa in 1931-32 and 1932-33 and we may regard the establishment of T. 58 as a very high yielder as practically proved. The results will be published in detail after experiments at Pusa and at Karnal during the next (1933-34) season.

Sixteen promising types were grown on large observation plots to ascertain which of them are suitable for a yield test. The results are shown in statement No. II appended in the end. Types 46 and 67 seem to be the best in yield and quality and will be grown next year on a large scale to get sufficient seed for future yield trials. T. 28 is the best of the small white seeded types and has kept up its position.

Gram crosses. The following crosses were studied in the year under report :—

F_3 generations of

(1) T. 9 × T. 13
(2) T. 12 × T. 11
(3) T. 82 × T. 1

F_2 generations of

(1) T. 39 × T. 2
(2) T. 2 × T. 39
(3) T. 52 × T. 11
(4) T. 21 × T. 11
(5) T. 82 × T. 1
(6) T. 1 × T. 82

The inheritance of colour in flower has been studied fully and the results are being published.

So far three factors for colour in the petal have been identified. These factors are, a factor B for blue colour, a factor P which modifies blue to pink and a factor W which inhibits the development of green colour on the edge of the standard. The factor P by itself in the absence of B has no effect on the colour of the flower and white flowers therefore may be of several different genotypes. The development of greenness on the edge of the standard is controlled by the presence of W and is independent of the other colour factors P and B.

The inheritance of seed characters such as colour, shape, surface, etc., is being studied and will form the subject of a later paper.

Oats

Last year a yield trial of some Pusa oats was laid out in randomized blocks. Thirteen varieties were replicated five times in blocks of 1,000 square feet each. The trial was repeated also in the year under report and the results are given below :—

Average yield in lb. per acre

Hybrid	Yield in lb.	Rank
A	1,594·3	10
B	1,136·1	13
C	2,077·8	5
D	1,894·9	7
E	1,899·2	6
F	1,633·5	9
G	2,186·7	4
H	1,568·1	11
I	1,542·0	12
J	2,339·2	3
K	1,677·1	8
B. S. 1	2,432·0	2
B. S. 2	2,504·7	1
General mean	1,880·05	
Standard error of mean difference	118·01	

Barley

Last year the best types of Pusa barleys were attacked by rust very badly. This year all the 24 types were grown on small scale to ascertain their susceptibility to rust at Karnal under irrigated conditions. No type proved to be immune, but some are more resistant to rust than others. Types 12, 17, 21 and 23 seem to be the least attacked and will be tried in future. Type 21 was one of the types most severely affected by this disease in the previous season, and it appears that the incidence of disease in any particular type is subject to wide seasonal variation.

Brassicae

Representative cultures of different species of Brassicae were grown both at Pusa and Karnal. A tentative classification has been made.

Brassicae crosses. Some crosses between turnip and five Brassica varieties were made at Pusa and the F_1s were grown at Karnal. The F_1 plants were intermediate in thickness of root and flowering time and had much more vigorous growth than either parent. The percentage of pods formed under bags in different plants of the F_1 generation was as follows :—

Toria (*B. napus* Linn. var. dichotoma Prain).	×	Turnip (B. *campestris* subspe. *rapa*) . . . . . 2·87 to 9·35
Turnip	×	*Toria* . . . . . 1·66 to 16·62
Turnip	×	Yellow *sarson* (*B. campestris* Linn. var. *sarson* Prain) 4·69 to 77·12
Turnip	×	Black *sarson* late (*B. campestris* Linn. var. *oliefera* Prain) . . . 3·79 to 32·25
Black *sarson* late	×	Turnip . . . . . 0 to 12·4
Turnip	×	Burma *sarson* (*B. oleracea* Linn. var. *chinesis* Prain) 2·15 to 60·00
Burma *sarson*	×	Turnip . . . . . 0 to 40·62

The cross between turnip and ordinary *rai* was not successful.

F_2 generations of crosses between yellow *sarson* and *toria* and yellow *sarson* and black *sarson* were also grown. Yellow *sarson* is a self-fertile species having yellow seeds, while *toria* and black *sarson* are both self-sterile with red seeds. F_1 plants were self-fertile with red seeds.

Statement showing the segregation of seed colour in F_2

Name of cross	No. of F_1 plants	Frequency in F_2		Total
		Red seed	Yellow seed	
Yellow *sarson* 75-1 × *Toria* 48-1	1	55	9	64
	3	21	5	26
	5	37	3	40
Total observed		113	17	130
Expected on 3 : 1 basis		97·5	32·5	
Toria 48-1 × Yellow *sarson* 60-1-5	1	28	9	37
	12	59	12	71
	17	31	6	37
Total observed		118	27	145
Expected on 3 : 1 basis		108·75	36·25	
Yellow *sarson* (60-1-5) × Black *sarson*.	1	30	3	33
	3	40	7	47
	4	33	9	42
Black *sarson* × Yellow *sarson*	1	11	4	15
	4	49	2	51
Total observed		163	25	188
Expected on 3 : 1 basis		141	47	

It will be seen from the above results that the frequency of yellow-seeded plants is much less than the expected number. This may be due to the presence of a lethal factor in yellow-seeded plants and will be investigated during the course of detailed study.

To study the inheritance of sterility, fifteen plants in each F_1 culture were bagged and the percentage of pods formed was noted. Plants in which the percentage was below 30 were taken as sterile. The segregation of this character in F_2 is given below.

Statement showing the segregation of sterility in F_2

Name of cross	No. of F_1 plants	Frequency in F_2		Total
		Self-fertile	Self-sterile	
Yellow *sarson* × *Toria*.	1	10	5	15
	3	14	1	15
	5	13	0	13
Total observed		37	6	43
Expected on 3 : 1 basis		32·25	10·75	

Name of cross	No. of F_1 plants	Frequency in F_2		Total
		Self-fertile	Self-sterile	
Toria × Yellow *sarson* 60-1-5	1	15	0	15
	12	11	4	15
	17	11	4	15
Total observed		37	8	45
Expected on 3 : 1 basis		33·75	11·25	
Yellow *sarson* × Black *sarson*	1	7	8	15
	3	13	2	15
	14	14	2	16
Black *sarson* × Yellow *sarson*	1	8	1	9
	4	8	6	14
Total observed		50	19	69
Expected on 3 : 1 basis		52·5	17·5	

From the above results it is clear that red colour in seed coat and self-fertility are dominant over yellow seed coat and self-sterility.

These results confirm our former observations made on natural crosses. A type which has red seed with all other characters of yellow sarson has already been fixed, which means that by crossing a self-fertile species with a self-sterile one we can produce self-fertile types with some characters of self-sterile types.

III. SEED DISTRIBUTION

The following seeds were distributed from the harvest of 1932-33 :—

	Mds.	Srs.
Wheat—		
Pusa 4	115	2
,, 12	105	0
,, 80-5	43	25
,, 111	23	5
,, 112	7	20
,, 113	8	0
,, 114	13	35
,, 120	5	38
,, 165	5	38
Gram—		
T. 17	45	0
T. 58	32	10

IV. STATEMENTS SHOWING THE YIELDS OF CROPS

1. Outturn of different crops during the year 1932-33

Crop	Plot No.	Area in acres	Actual outturn in lb.	Outturn per acre in lb.	Bushel-weight of 5 calculations in lb.	Highest outturn per acre in 1931-32 in lb.
General Area—						
Gram—T. 28	42	3·18	5,449	1,317		904
T. 58	44	1·90	3,971	2,090		
	45	1·80	5,264	2,925		896
Local	50	1·29	2,675	2,074		
	51	1·40	2,554	1,824		914
T. 17	46	1·70	4,243	2,497		1,435
	47	1·60	3,753	2,345		
	48	1·49	3,025	2,030		
	49	1·40	3,136	2,241		
Wheat—P. 111	1 to 5	4·63	7,624	1,646	64·4	1,419
P. 80-5	6 to 16	13·66	19,384	1,418	65·24	1,693
P. 4	17 to 23	16·47	24,052	1,460	63·3	1,437
P. 114	29 to 34	8·33	13,841	1,662	65·0	1,591
P. 12	35 to 41	15·50	26,113	1,685	62·9	1,166
Oats—Hybrid J	26	1·00	1,689	1,689	37·1	
B. S. 1	24, 26, 27, 28.	7·26	11,902	1,640	32·8	1,613
Experimental Area—						
Wheat—P. 165	1	1·09	2,575	2,362	65·8	2,072
	11	0·92	2,562	2,785		
P. 120	4	1·17	2,679	2,290	65·2	1,582
	10	1·14	2,538	2,226		
P. 112	3	1·17	2,591	2,214	64·1	1,339
P. 113	2	1·17	2,827	2,415	63·9	2,226
Rice Area—						
Peas—Local		3·79	1,312	346		
Nagpur		0·42	307	732		
T 14-1		0·96	553	576		
Fodder		0·91	7,732	8,497		
Building Area—						
Toria—local	1	0·68	732	1,076		
Sarson—local	2	0·84	1,363	1,624		
Rice Area—						
Red Rice	2	0·27				
	3	0·62				
	4	0·46				
		1·35	2,154	1,595		
White Rice	1	0·36				
	2	0·98				
	3	0·90				
	4	0·96				
		3·20	5,947	1,857		

2. Outturn of promising types of gram sown in plot Nos. 5 and 6 of Experimental Area

Types	Actual outturn in lb.	Area	Outturn per acre in lb.	Rank
T. 3	182	0·136	1,340	
T. 6	254	0·136	1,869	
T. 26	283	0·136	2,080	
T. 28	320	0·136	2,278	4th
T. 46	328	0·136	2,412	1st
T. 47	322	0·136	2,367	2nd
T. 48	193	0·136	1,416	
T. 49	195	0·136	1,432	
T. 50	266	0·136	1,959	
T. 51	289	0·136	2,125	
T. 53	295	0·136	2,171	
T. 54	281	0·136	2,064	
T. 66	287	0·136	2,109	
T. 67	328	0·136	2,412	1st
T. 69	190	0·136	1,402	
Local	320	0·136	2,351	3rd

REPORT OF THE SUGARCANE EXPERT

(Rao Bahadur T. S. Venkatraman, B.A., I.A.S.)

It is with profound regret that I have to record the passing away in February 1933 of Dr. C. A. Barber, C.I.E., the founder of the station. It is a great pity that he should thus have been snatched away at a time when the Indian sugar industry is rapidly expanding, primarily as a result of the activities of the station founded by him in October 1912.

I. CHARGE AND STAFF

I held charge of the office of Sugarcane Expert throughout the year. Mr. N. L. Dutt held charge of the post of Second Cane Breeding Officer till the 8th May when he left on nearly three months' leave.

The year's crop at the Karnal Sub-station was the first full year crop to be grown there. This sub-station is steadily taking shape and the bulk of the buildings was completed during the year.

II. SUGARCANE BREEDING (MAINLY SUB-TROPICAL TYPES)

(*a*) Breeding technique

(*i*) *Controlling time of arrowing.* By planting at two seasons (*viz.*, December and April) and under different soil conditions (*viz.*, garden and wet lands), it has been possible to synchronize, for cross-fertilization purposes, the arrowing of most of the parents desired. A period of as many as 25 days was bridged over by this method.

(*ii*) *Preparing nursery seedlings for transport.* Some attention was devoted to the best manner in which seedlings could be transported as seedlings from Coimbatore to various stations in sub-tropical India. The object is to give the new seedlings a chance to grow under sub-tropical conditions even from the very early stages. After some experimentation it was found that one successful method was to partially starve the seedlings and prune them immediately before the railway journey. The earthen

PLATE III.

Young seedlings in earthen pans pruned and packed for railway journey.

Batch of seedlings treated as in top picture after a railway journey of 72 hours over a distance of nearly 2,000 miles.

seed pans were protected by being wrapped round with paddy twist at the sides to avoid knocks and breakage during the journey. An attendant travelled with the seedlings to water them at railway junctions as needed. Thus transported, a batch of 5,000 seedlings showed very little mortality after a journey of 72 hours in a covered railway wagon provided with ventilators (Plate III).

(*b*) Interspecific hybridization

(*i*) *Parents employed.* The arrowing during the year was satisfactory and enabled a large number of crosses to be made. P. O. J. 213, Co. 213 and Co. 221—pollen infertile mothers giving satisfactory germinations—were crossed with P. O. J. 2878, Co. 281, Co. 312 and Co. 313. From the parentages of the canes employed as parents, it will be seen that most of the resultant seedlings would have in their genetic composition the blood of at least three different species of *Saccharum*, one of them being *Saccharum spontaneum* and the second an indigenous Indian cane.

(*ii*) *Seedlings of the previous year.* Eleven thousand seedlings which completed their life-cycle during the year and consisting of hybrids between Co. 213, Co. 281, Co. 290 and Co. 313 were carefully studied and 39 selections made for further propagation and testing. It was found that Co. 313 introduced into the resultant seedlings good habit and satisfactory juice quality.

(*c*) Intergeneric hybridization

(*i*) *General.* Specimens of arrows of hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf. were despatched to Kew, the meeting of the International Society of Sugarcane Technologists at Porto Rico and to Dr. Brandes at Washington. The specimens attracted some attention at the International Society and comment was made on the arrow characters and the comparatively large size of the seeds as compared with those in interspecific crosses. Mr. H. B. Cowgill, who has been specializing in the study of *Saccharums* and examined the Washington specimens, finds in the arrows " ample morphological evidence of their hybrid nature ".

(*ii*) *Parents employed.* Till the past season P. O. J. 2725 alone was employed on the mother side and *Sorghum Durra* Stapf. on the father side. During the current season it was possible to extend the range of parents on either side by the planting of parents at different times and under different soil conditions as

already mentioned. The parents employed during the season are given below :—

Sugarcane mothers	*Sorghum fathers*
P. O. J. 2725 . .	*Sorghum Durra* Stapf.
P. O. J. 213 . .	*Sorghum guineense* Stapf. Nigeria.
Co. 213 . . .	*Sorghum guineense*. Nigeria.
Co. 221 . . .	*Sorghum cernuum*. Palestine.
	Sorghum halepense. Palestine.
	Sorghum halepense. Coimbatore.
	Sorghum verticilliflorum Stapf, Uganda.
	Sorghum sudanense. Kansas, U. S. A.

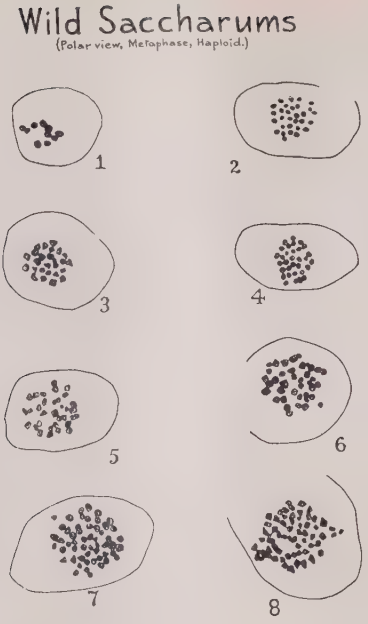
Most of the above interesting *Sorghum* parents were kindly supplied by Mr. H. C. Sampson, Economic Botanist at Kew, to whom my thanks are due.

(*iii*) *Characters of the population.* The hybrid populations are showing quite a variety of forms, the bulk of them being very similar to sugarcanes. The F_1 generation—which in the case of the sugarcane shows variations—while containing forms similar to the sugarcane does not include types very similar to the *Sorghum* parent. The populations often include quite a number of types which nestle close to the ground, show limited cane formation, possess thickish leaves and are obviously of no value as sugarcanes. During the season as many as 8,000 such hybrids, representing various combinations, have been planted for a full year study. It would appear that cane parents other than P. O. J. 2725 are likely to give a better class of economic types.

(*iv*) *Back-crosses with Sorghum and Saccharum spontaneum.* Some of the hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf. were back-crossed with *Sorghum Durra* Stapf. The resultant plants, while very interesting from the academic view point, do not appear to contain economic types. Some of these hybrids were crossed with the Coimbatore form of *Saccharum spontaneum*. The resultant plants are much like the thin-stemmed sugarcanes.

(*v*) *Juice quality.* Certain features common to the selected hybrids between P. O. J. 2725 and *Sorghum Durra* Stapf. are (1) early fitness for milling under tropical conditions (from six to seven months), (2) further improvement in juice quality when

PLATE IV.



1 and 2 Two different forms of *Saccharum munja*, 3 *spontaneum* (Dehra Dun), 4 *spontaneum* (Godavery, Madras), 5 *spontaneum* (Coimbatore, occurring on canal bunds), 6 *spontaneum* (Dacca, Bengal), 7 and 8 Thin-stemmed and Thick-stemmed forms of *spontaneum* (?) from Sumatra.

Badila Co. 285 Co. 281 Badila

(at the Paddy Research Station, Aduthurai, Madras Presidency)

kept in the field leading to high sucrose values, and (3) comparatively high purities. One of these recorded over 23 per cent. sucrose in juice and a second over 21 per cent.

These hybrids often show a marked and rapid improvement in juice quality with the onset of conditions favourable to ripening (Table I).

TABLE I

Analyses of sugarcane × sorghum hybrids at interval of a fortnight. Age of crop at second round, 6 months and 3 weeks

Variety	Date of analysis	Brix per cent.	Sucrose per cent.	Co-efficient of purity
	1932			
Co. 351 . . .	14th September .	16·75	13·18	78·7
	30th September .	18·99	15·78	83·1
Co. 352 . . .	14th September .	15·46	12·15	78·6
	30th September .	17·98	14·91	82·9
Co. 353 . . .	14th September .	17·14	13·96	81·5
	30th September .	19·59	16·49	84·2

III. RESEARCH AND INVESTIGATIONS

(*a*) CYTOLOGICAL STUDIES

One interesting investigation during the year was the study of chromosomes in (*i*) wild *Saccharums*, (*ii*) bud sports of Co. 213 and (*iii*) interspecific and intergeneric crosses with *Saccharums* by Botanical Assistant Thakur Suraj Narain Singh, who showed great diligence and enthusiasm for the work. He finds difference in the chromosome numbers of the different types now included under *Saccharum spontaneum* (Plate IV). In the previous report an account was given of the vegetative sports from Co. 213 and the manner in which they differed in their juice qualities and type of root-systems, the last being illustrated with photographs. Mr. Singh has now found differences in their chromosome numbers as well.

(*b*) SHOOT AND ROOT STUDIES

The periodic shoot weighments and root dissections of varieties under test mentioned in the previous report have yielded a method by which to select canes suitable to particular localities,

and it would appear important to study the manner in which the different varieties pass through the critical period for cane in the tract.

(c) Influencing arrow fertilities

Sub-tropical canes like Saretha and Chin which showed male sterility during the early years of acclimatization at Coimbatore had been developing abundance of fertile pollen in subsequent years. Fresh material of these canes was obtained during the year and planted under different soil conditions to try and discover the factors responsible for their male sterility during the earlier years.

(d) Juice analysis of varieties under test

It is not every sugarcane testing station that has full facilities for periodic analysis of the varieties under trial. Analyses at such stations are at present often dependent upon the ability and convenience of a central laboratory deputing one of the staff for carrying out the analyses. The experiment was therefore laid to find out if, by sending the canes properly packed and as railway parcels to a central laboratory, such analyses could not be done there. Results (Table II) show that there is little difference even after railway journeys extending over a period of three days. The preservation and packing of canes adopted in these sendings was the one described in a previous publication* (Venkatraman, 1920).

Table II

Juice analyses of sugarcane varieties before and after railway journey of three days

Variety	Brix per cent.		Sucrose per cent.		Co-efficient of purity	
	Before	After	Before	After	Before	After
Co. 366 .	17·01	16·89	14·56	14·32	85·6	84·8
Co. 380 .	19·77	19·90	17·39	17·63	87·9	88·6
Co. 370 .	17·31	17·19	15·03	14·79	86·8	86·1
Co. 376 .	19·15	18·84	16·76	16·42	87·5	87·1
Co. 341 .	18·45	18·49	16·04	15·78	86·9	85·4
Co. 374 .	20·94	20·90	18·97	18·91	90·6	90·5

*Agri. Jour. of India, Volume XV, Part 2 (March 1920).

IV. RESEARCH AND INVESTIGATIONS BEARING MAINLY ON THICK CANE BREEDING

(N. L. Dutt, M.Sc.)

(*a*) Breeding

The bulk crossing during the year was of (1) *Vellai* × Co. 243, (2) P. O. J. 2878 × Co. 290 and (3) P. O. J. 2725 × 247 B. The first named combination has already given us the seedling Co. 402, which has been reported to have done well at several places. Besides, several other experimental crosses were made to ascertain the type of seedlings obtained.

(*b*) Selection of seedlings

Out of 330 new seedlings grown in the test plots, five were raised to the status of Co.'s and their parentages are given elsewhere in this report (Co. 416 to Co. 420).

(*c*) Chromosome numbers

The haploid chromosome number was determined in the following varieties by making counts from the polar views of the equatorial plates of the pollen mother cells. In certain cases the number was confirmed by taking counts from diakinesis also. The varieties studied were Poovan, Chittan, Creole and Saretha. The last mentioned variety had an added interest in that it was expected to find in it the membranous body mentioned by Dr. Bremer as characteristic of the Indian canes. In quite a large number of sections examined, the characteristic body has not been found even in a single section. It is proposed to cut more sections before definitely coming to the conclusion that the body in question is absent in Saretha. Material has been fixed of Striped Mauritius, P. O. J. 1410, C. A. C. 87, Karun, Fiji B (Badila), and Kaludai Boothan.

(*d*) Chromosome numbers in relation to size of nuclei

Dr. Bremer has established a relationship between the haploid chromosome number and the size of nuclei of the pollen mother cells at diakinesis in certain varieties of *Saccharum officinarum* as also other forms of *Saccharum*. He found that if the radius of the microsporocyte in microns was raised to the third power, it

approximates to ten times the haploid number, *e.g.*, for Glagah, which has 56 haploid chromosomes, r^3 was 588 and 539 or not far from 560, that is, ten times the haploid number.

To ascertain the bearing of the above ratio on certain of the canes grown in India, measurements were made in Poovan, Chittan, Puri, *S. spontaneum* (Coimbatore) and Co. 205. The deviation from the above ratio was found to be over 70 per cent. in Poovan, *S. spontaneum* and Co. 205; and 27 per cent. and 50 per cent. respectively in Chittan and Puri. Subsequently measurements were also made in Saretha and the above ratio has been realized in this case. The haploid chromosome number in Saretha was found to be 46 and the r^3 came to 439 which is fairly close to ten times the haploid chromosome number.

(*e*) Observations on male nuclei

The presence or otherwise of the four male nuclei in the seedlings of such canes as showed four male nuclei in previous years was pursued in greater detail. Four male nuclei were noticed in certain seedlings which contained the blood of B. 3412, P. O. J. 1410 and C. A. C. 87. In addition to the varieties already reported, four male nuclei were noticed in Co. 290, A. 2, Co. 223, D. 1135 and *S. spontaneum* (Coimbatore), though the occurrence of four male nuclei was rather rare in the three last mentioned varieties. Observations were made on the migration of male nuclei *in vitro* and *in vivo*. The migration was noticed to have taken place in a greater number of pollen tubes on stigmas in nature than in those growing in culture media.

(*f*) Stigma receptivity

Observations were made regarding the applicability of stigmatochromy for the determination of receptivity of the stigmas of certain sugarcane varieties. Stigmas were immersed in Robinson's argentiferous solution. The results were not conclusive and it is proposed to try different streugths of the solution next season.

(*g*) Controlling time of arrowing

The main object in conducting this work is to increase the range of possible crosses. As reported last year, the flowering in the sugarcane was sought to be controlled by three methods, by topping, by subjecting to sub-normal day length and by etiolation. Results obtained in the last mentioned were not conclusive. Greatest success was, however, obtained with the second method.

P. O. J. 2725 and Co. 285 (early flowering varieties) were subjected to six hours and four hours day lengths for a period of 35 days and 45 days respectively. The treated canes flowered 14 days and 11 days earlier than the controls. The percentage of flowering in P. O. J. 2725 was 98 in the control canes and 76 in the treated canes, while in Co. 285, 75 per cent. of the canes flowered in the control and only 30 per cent. in the treated canes. It was also noted that the arrows in the treated canes were rather short. Confirmatory results were obtained with regard to the topping experiment and the results obtained during the current year are given in the following table. It is proposed next year to do the experiment on a larger scale in the varieties P. O. J. 2725, P. O. J. 2878 and Co. 285.

TABLE III

Results of topping experiment, 1932

Variety	Once topped		Twice topped		Control	
	Date of flowering	Percentage of flowering	Date of flowering	Percentage of flowering	Date of flowering	Percentage of flowering
P. O. J. 2725	21-9-32	72	24-9-32	74	15-9-32	84
P. O. J. 2364	30-9-32	90	28-9-32	70	26-9-32	74
P. O. J. 2878	4-10-32	80	16-10-32	37·5	1-10-32	85
Co. 285 .	30-9-32	93	5-10-32	65	28-9-32	73
Co. 290 .	8-11-32	78	7-11-32	63	6-11-32	86

(*h*) GERMINATION IN THICK CANE SEEDS

The variety Vellai was crossed with five different varieties to ascertain the influence of the pollinating parent on seed germination. Equally weighed quantities, 3 grms. per seed pan, were sown. It was found that the germinations in Vellai × Clagah and Vellai × Co. 205 were twelve and fifteen per pan respectively and eleven and eighteen for Vellai × Kaludai Boothan and Vellai × P. O. J. 2878 respectively. The best combination from this point of view was Vellai × B. 3412 which gave 246 germinations per pan. It was further found that Co. 403, a seedling of Vellai, gave better germination when crossed with P. O. J. 2878 as compared with the combination Vellai × P. O. J. 2878, the respective figures being 36 and 18 per seed pan.

V. RECEIPTS AND DISTRIBUTIONS

(*a*) Receipts

The collection of *Sorghums* was reinforced by three types from Siera Leone, three from Kew and two from the Bombay Presidency.

(*b*) Distributions

(*i*) *As true seed.* Preserved sugarcane seeds were sent to the Economic Botanist at Shahjahanpur in the United Provinces, to the Sugarcane Specialist at Mushari in Bihar and to the Sub-station at Karnal in the Punjab for sowing.

(*ii*) *As seedlings.* Five thousand seedlings of Co. 285 were sent to the Sub-station at Karnal in a special through wagon. Another consignment of 5,000 seedlings of parentages likely to be useful in the United Provinces were sent in a similar manner to the Sugarcane Research Station at Shahjahanpur.

(*iii*) *As canes.* Four hundred and twelve packets containing 84 varieties, mostly Co. seedlings, were distributed to various places in India and fifteen parcels sent overseas, *viz.*, to Egypt, Kenya and Formosa.

VI. PERFORMANCE OF COIMBATORE CANES

(*a*) Coimbatore canes in sub-tropical India

The area under improved Coimbatore canes in the main sugarcane tracts of India is steadily on the increase. The official figures for 1932-33 are not yet available, but those for 1931-32 came to about 39 per cent. of the cane area. The increased yields from the Coimbatore canes combined with the wider range of conditions under which they are able to grow, constitute one important factor in the phenomenal development of the Indian sugar industry, particularly within the last two years.

Among the new canes, Co.'s 313 and 331 are perhaps the most promising, followed by Co. 299, Co. 326, Co. 301, Co. 244 and Co. 300. Co. 285 is justifying expectations entertained at the time of selection as likely to be an improvement on and replace Co. 205. In the farm at Patna this cane has shown considerable resistance

to conditions of water-logging. Among the latest productions, Co. 347, Co. 349 and Co. 350 are showing promise in the United Provinces.

(*b*) Coimbatore canes in tropical India

It is hardly a couple of years since the first batch of Coimbatore seedlings of the thick type was distributed for trial and these are yet in comparatively small plots at the various stations. Preliminary reports about their performance have been quite satisfactory, Co. 402 and Co. 408 being apparently two of the most promising. In the preliminary test plots at Coimbatore, there are a certain number of the later seedlings showing better performance than the above two. In recent years hybrids have been raised between the best Coimbatore types and the best foreign canes like P. O. J. 2878 in connection with the breeding of improved canes of the thick class. The *jaggery* (crude sugar) of Co. 408 has shown very good quality followed by that of Co. 402. Largely through the personal interest of the present Director of Agriculture, Madras, use for the medium type of Coimbatore canes has been found even under Madras conditions. Even a comparatively thin medium cane like Co. 281 has yielded in certain localities in Madras higher tonnages than very thick types like Badila (Plate IV). The chief value of this class of canes in localities now under thick types would appear to lie in the comparative less care and attention they need and hence lower costs of cultivation.

(*c*) Coimbatore canes in foreign countries

In South Africa, Co. 290 is reported to have yielded 31 per cent. more sugar than Uba and to be free from *sereh*. In Louisiana, Co. 281 has shown excellent keeping qualities on windrowing. In Porto Rico, Co. 281 has been found to be comparatively less susceptible to mosaic than P. O. J. 2878, Badila and B. H. 10 (12).

(*d*) Sugarcane-sorghum hybrids

Madras has probably got the largest data so far on these hybrids, due again to the personal interest of the Director of Agriculture, Madras. In certain of the stations these are planted every month and analysed periodically to find out the best way of fitting these short-duration canes into the agricultural programme of the tract. The first published report on these hybrids has been from Anakapalle, the Sugarcane Research Station for Madras (Table IV).

TABLE IV

Results of chemical analysis of sorghum crosses, 1931-32 (Sugarcane Research Station, Anakapalle, Madras)

Field No. 40. Planted on 1st September, 1931. Harvested on 9th April, 1932.

Variety	Brix per cent.	Sucrose per cent.	Glucose per cent.	Co-efficient of purity
Co. 351	19·57	17·44	0·31	89·10
Co. 352	20·47	17·90	0·31	87·46
Co. 353	17·17	14·27	0·69	83·12
Co. 354	18·67	16·08	0·64	86·12
Co. 355	17·17	13·92	0·80	81·08
Co. 356	15·37	11·75	0·82	76·45
Co. 357	17·97	14·95	0·68	83·20

The *gur* (crude sugar) obtained from most of these hybrids has been of a very satisfactory nature.

VII. THE KARNAL SUB-STATION

(*Financed by the Imperial Council of Agricultural Research*)

(*a*) GENERAL

The main object of starting this sub-station was to give scope to Coimbatore for testing under sub-tropical conditions whole series of new canes without preliminary rejections at Coimbatore and for obtaining first hand knowledge of growth conditions in North India. Along with this, it was also decided to explore the possibilities of obtaining viable seeds and of effecting crosses at Karnal itself.

(*b*) TESTING OF NEW CANES IMPORTED FROM COIMBATORE AS SETTS

The year's crop, considered one of the best in the tract, included 100 seedling canes (imported from Coimbatore as canes), which were grown for purposes of testing in ten to sixty rows (20 ft. long) according to the quantity of material available of each. Comparatively simple methods consisting, in the main, of periodic weighments of the above-ground portions and root dissections *in situ* were laid down for studying the merits of the new canes as

compared with the *desi* or standard canes of the locality. These studies have led to useful results, certain of which are briefly described below :—

(*i*) *The life-cycles of the different varieties.* Besides germination and habit notes, two very important characters in a cane crop, periodic weighments were recorded of the shoot or above-ground portions of at least a whole row of canes to watch the manner in which the different varieties build up their tonnages at harvest. The data recorded included weight of the whole above-ground portion, number and weight of millable canes and quantity of juice obtained at harvest.

The local cane in the tract is Lalri, while Co. 205 and Co. 285 are the two Coimbatore canes that are replacing or are likely to replace the local variety. An examination of the data showed that Co. 312, Co. 357 and Co. 313 are easily superior not only to the local cane but also to Co.'s 205 and 285. Co. 357 is a hybrid between sugarcane and sorghum.

(*ii*) *Resistance to adverse summer conditions.* The severity of summer conditions in sub-tropical India is well known. As the canes are planted at the beginning of summer the manner in which a new cane withstands this period is a character of considerable importance in the selection of suitable types. Weighments of the above-ground portions of whole rows, once at the beginning of summer and a second time at the end of it, have yielded useful data on this point. Table V gives the figures for five of the best canes in this respect as compared with the local variety.

TABLE V

Manner in which different canes passed through the summer at Karnal

Seedling Number (1)	Weight of a whole row (above-ground portion) in lb.		Column 3 divided by Column 2 to indicate resistance to summer conditions (4)
	At beginning of summer (2)	At end of summer (3)	
Co. 317	4·5	68	15·1
Co. 312	10	118	11·8
Co. 341	10	84	8·4
Co. 205	12·5	88	7·0
Co. 285	12	68	5·7
Lalri	14	60	4·3

The statement shows the superiority of certain of the later Coimbatore productions in this respect. In pursuance of these results, a plot of unirrigated canes to test such seedlings has been laid for the next year.

(*iii*) *Maturity and juice quality.* Periodic refractometer readings were recorded from the beginning to end of the cane crushing season in the tract. This has yielded information on (1) the 'earliness' or 'lateness' of the varieties, (2) relative juice qualities and (3) period during which each variety maintains its juice quality without appreciable deterioration. It is felt, however, that conclusions from these data could be safely drawn only next season when the new canes will be grown in a larger number of rows. At harvest a complete juice analysis was made of the different canes under test.

(*c*) Germination of sugarcane seeds at Karnal

Of the 400 seedlings obtained in 1931 from seed germinated at Karnal, half a dozen showed satisfactory qualities, two of them being almost fit for distribution. These were from Co. 285 reported to be replacing the earlier cane Co. 205 in the Punjab. It was thought best, however, to get data on these new seedlings for yet another year and on a field scale before actual distribution.

(*d*) Viable seeds at Karnal

Examination of arrows revealed stray viable seeds in hardy canes like Co. 205 and Co. 326 when the arrows are put forth in March-April. It might later become possible to plant in such a manner as to delay the arrowing of parents till the approach of summer at Karnal.

VIII. PARENTAGES OF CO. SEEDLINGS

Parentages of seedlings raised to the status of Co.'s during the year are given in Table VI.

Table VI

Parentages of Co. canes

Seedling Number	Parentage
Co. 398	P. O. J. 2725 × *Sorghum Durra* Stapf.
Co. 399	P. O. J. 2725 × *Sorghum Durra* Stapf.
Co. 416	Vellai × Co. 243.
Co. 417	P. O. J. 2725 × Co. 290.
Co. 418	P. O. J. 2725 × Co. 290.
Co. 419	P. O. J. 2878 × Co. 290.
Co. 420	Karun × Co. 243.

IX. TRAINING

Two students from the Punjab, deputed by the Department of Agriculture of the province, joined for training in November 1932 for a one-year course.

X. MISCELLANEOUS

A set of herbarium specimens of sugarcane × sorghum hybrids was sent to Dr. E. W. Brandes, Head of the Division of Sugar Plant Investigations, and another to Mrs. Agnes Chase of the United States Department of Agriculture.

XI. PROGRAMME OF WORK FOR 1933-34

Major

The breeding of medium and thick canes will be carried on with the object of effecting further improvements, covering new tracts or cheapening cost of cultivation.

Attempts will be made to secure still better germinations among thick cane seeds.

Studies on the genetics of the sugarcane will be continued and extended with the help of the Geneticist sanctioned by the Imperial Council of Agricultural Research.

Minor

Studies in sugarcane pollen, controlling time of arrowing and of the forms of *Saccharum* will be continued.

XII. PUBLICATIONS

(1) Venkatraman, T. S., and Hussainy, S. A. — Sugarcane Varietal trials for selecting suitable Improved Types. *Agri. and Live-stock in India*, Vol. III, Pt. I, page 1.

(2) Dutt, N. L., and Subba Rao, K. S. — Observations on the Cytology of the Sugarcane. *Ind. Jour. Agri. Sc.*, Vol. III, Pt. I, page 37.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. N. Mukerji, B.A., B.Sc.)

I. CHARGE

Mr. J. N. Mukerji, Assistant Agricultural Chemist, held charge of the Section throughout the year.

II. EDUCATION

One post-graduate student finished his course in October 1932, and two are continuing their studies.

III. METEOROLOGY AND DRAIN-GAUGES

The usual meteorological records and records of drainage from four drain-gauges were maintained. In connection with drain-gauges, sann-hemp and wheat crops from the gauges and 24 samples of drainage waters were examined.

At the request of the Director General of Observatories, Poona, monthly averages of humidity at eight hours, and monthly averages of maximum and minimum temperatures at Pusa for ten years from 1921 to 1930 were worked out and supplied for the use of the Officer-in-Charge of Agricultural Meteorology. Besides these, other data, such as monthly rainfall for the last 27 years and drain-gauge percolation figures, were also supplied.

IV. GENERAL ANALYTICAL WORK AND ASSISTANCE GIVEN TO OTHER SECTIONS

1. General Analytical Work

The following samples were analysed and reported upon :—

Soils	15
Manures	11
Feeding stuffs	32
Oil-seeds	125
Sugarcane	307
Milk	865
Water	1
Drugs	10
Miscellaneous	14

Besides those made in connection with the work of this Section, the analyses made for other Sections of the Institute and for persons outside Pusa are indicated briefly as follows. For the Agricultural Section, nine samples of manures, one of silt, 203 of sugarcane in connection with the farm's variety test, manurial experiments, etc., 28 of feeding stuffs, and 865 of milk were analysed. The milk samples from two leading cows and two lowest yielders in the herd were examined twice every alternate day in order to see the variation in the fat content under special handling. These cows were milked four times daily with equal intervals between milkings and were kept on low concentrates. For the Botanical Section, 125 samples of linseed, two of manures, three of wheat, 10 of *ganja* (Indian hemp), and one of commercial formalin were analysed. The wheat samples were examined for their starch, gluten, and maltose contents ; the diastatic activity and gas production with regard to their baking qualities were also determined. The gas production from wheat flour which was bleached by Novadelox process was much less than that from (1) wheat dry cleaned and unconditioned and (2) wheat conditioned and tempered for milling. Bleaching by a chemical agent thus had the bad effect of reducing the gas production. Besides these, chemical analysis of 8 composite samples of soil taken from the areas under the Botanical Sub-station at Karnal, and mechanical analysis of 36 individual samples from the same area have been completed. For the Mycological Section, 36 samples of sugarcane from the mosaic tonnage plot, four of soil, and four of fungal cultures were examined, and for the Entomological Section, 66 samples of sugarcane were analysed in connection with the damage done by topshoot borers, stem-borers, root-borers and termites, individually and collectively.

Five samples of soil were received from the Agricultural Officer, North-West Frontier Province. The three from Peshawar, though rich in manurial constituents, contained an abnormally high percentage of water-soluble salts and two from Bannu were deficient in phosphoric acid content. Two samples of soil, received from the Deputy Director, Land Records and Agriculture, Coorg, were found very poor in lime content, and one of them was also deficient in phosphoric acid. Two samples of sweet sorghum from the Sugarcane Specialist, Sugarcane Research Station, Mushari, contained about 5 per cent. sucrose and 1 per cent. glucose in juice. Eight samples of *ganja* (*Cannabis sativa*) received from the Excise Commissioner, Bihar and Orissa, were examined for their specific rotation and resin content with a view to find out their physiological activity, and five samples of barley malt received from the Manager, Solon Brewery, were examined for diastatic activity, colour of wort, and cold water extract.

Examination of Methods of Analysis

(*i*) The estimation of sucrose in bagasse by Noel Deerr's method, using the bagasse digester, was tested to see if it was applicable in case of bagasse obtained from a three-roller mill. The 45 minutes digestion at boiling temperature as recommended in this method was found insufficient to extract all the sugars from the coarsely cut bagasse pieces. The time of digestion for complete extraction was found to be at least one hour.

(*ii*) Helige Pehameter for determining the pH value of soils in the field was tested with Jorhat soil, to which had been added increasing proportions of lime, and also with Solon soil and Pusa soils. The values of pH obtained by it deviated from those obtained by the quinhydrone electrode method by 0·2 to 0·3. For field work the apparatus is likely to prove useful.

(*iii*) *Estimation of potassium.* The method suggested by Hibbard and Stout (vide *Journal of Association of Official Agricultural Chemists*, Vol. 16-I, 137-140), which is based on the precipitation of potassium as *potassium cobaltinitrate* by a cobaltinitrite reagent in the presence of 2 per cent. acetic acid solution, filtration of the fine precipitate through a bed of talc powder (specially treated and made free from organic matter), its subsequent oxidation by (0·01N) $KMnO_4$ solution and tiration of the excess $KMnO_4$ by a standard sodium oxalate solution, was tried in this laboratory and found to give fairly accurate results within certain limits. The method, however, is not reliable in the case of solution containing more than 5 mg. of potassium. Hibbard and Stout found that estimation of potassium by this method is possible in the presence of small quantities of difficult soluble substances as calcium sulphate and silica, but it has been found in this laboratory that even the presence of fairly large quantities of soluble ferric, calcium and magnesium salts (all of which are present in soil or plant extracts) as impurities does not interfere with the determination or with the result.

The authors have directed to add the potassium cobaltinitrite precipitate to a boiling solution of $KMnO_4$ but this procedure gives a slightly higher figure (as shown below) owing to the dilute (0·01N) $KMnO_4$ slightly losing its strength, when boiled in the presence of H_2SO_4.

K in mg. found by estimation	1·13	2·28	2·29	3·77	5·54
K in mg. actually present .	1·05	2·10	2·10	3·67	5·24

If, however, instead of adding the cobaltinitrite precipitate to a boiling solution of $KMnO_4$, a few cubic centimetres of the latter are run into the beaker containing the precipitate and then heated in the waterbath till decomposition is complete, better results are

obtained, even in the presence of ferric, calcium and magnesium salts as impurities, as is evident from the figures given below.

K in mg. found by estimation	1·97	3·90	4·90	9·40
K in mg. actually present	2·00	4·00	5·00	10·00

If in the above results, the factor for 1 c.c. of (0·01 N) $KMnO_4$ be taken as equivalent to 0·0639 mg. K instead of 0·0625 mg. K, as suggested by Hibbard and Stout, almost theoretical results are obtained (*vide* table below).

K in mg. found by estimation using factor 1 c.c. $KMnO_4$=0·0639 mgK.	2·006	3·975	4·996	9·730
K in mg. actually present	2·000	4·000	5·000	10·000

V. RESEARCH

1. Crops

Experiment on curing of tobacco. It was reported last year that the method of curing by picking the leaves from the stalk is more expensive and requires more space than the method of curing the leaves with stalks on. By the former it is possible to harvest all the leaves at the right stage of maturity, but with the latter it is not. The leaves on the plant do not all ripen at the same time so that the stalks are cut at such a time as will give the greatest number of the best leaves at the proper stage of ripeness. This causes a considerable sacrifice in both bottom and top leaves since the former are over-ripe and the latter still immature. In many cases, both methods are said to give satisfactory results when properly carried out and the question as to which is the better in any given case must be decided largely by the local conditions, such as the amount and kind of the labour supply, the barn space available, and the like. Although either method may give good results, there are undoubtedly differences in the character of the cured product. To understand the differences brought about by the two methods, it must be remembered that the leaves and the stalks remain alive for several days or even weeks after harvesting, depending on the condition in the curing shed. During this period of gradual starvation they are enabled to remain alive by means of the reserve food supply stored up during the ripening process, so long as they retain sufficient moisture. When the leaves are cured on the stalk, there is a movement of food materials from the leaves into the stalk, but when the leaves are picked, there is, of course, no chance of this movement from leaf to stalk to take place. The longer curing period and the movement of materials from the leaf into the stalk when curing on the stalk is practised, will affect the quality of the cured tobacco.

In order to ascertain the difference in character, two lots of tobacco, each of Adcock and Pusa Type 28, as already reported last year, were cured on racks by both these processes and the cured products were examined for their nicotine, sugar, starch, ash potash, amido nitrogen and albuminoid nitrogen contents. These constituents have been recognized by several investigators to possess a direct bearing on the quality of tobacco, and attention was therefore confined to the examination of these for studying the differences. Last year tobacco leaves cured with stalks on invariably showed a higher nicotine content than leaves cured without stalks. The starch and sugar contents, on the other hand, as evident from Table I, are invariably lower in the case of tobacco leaves cured with stalks than those cured without stalks. Owing to a longer curing period and to movement of food materials from the leaf to the stalk, there is, thus, in the case of leaves cured with stalks a greater destruction of the two carbohydrates than in leaves cured without stalks.

The amido nitrogen in tobacco represents, for the most part, harmless or even beneficial nitrogenous compounds and the conversion of albuminoids into amides is one of the most important results of the curing and fermentation. The albuminoids by themselves afford no indication of quality unless the proportion of amides is simultaneously considered. Similarly a high content of potash in tobacco will not improve its fireholding capacity unless it is present mostly in combination with organic acid together with a minimum amount of inorganic salts. Hence the ratio of albuminoid nitrogen to amido nitrogen, and the ratio of ash to potash, in tobacco will indicate its quality more properly than each of these constituents considered separately. A lower ratio in both cases will thus indicate a better quality and a higher ratio an inferior quality of tobacco.

An examination of Table I shows that curing tobacco leaves with stalks invariably tends to lower the albuminoid-amide ratio, but in most cases it raises the ash-potash ratio.

TABLE I

Description of tobacco	Method employed in curing	Nicotine	Starch	Total sugar	Albuminoid Nitrogen	Amido Nitrogen	Albuminoid N / Amido N	Ash	Potash	Ash / Potash
		%	%	%	%	%		%	%	
Adcock, harvested on 25th January 1932.	Leaves cured without stalk.	2·13	6·88	8·33	1·13	0·195	5·81	17·30	1·63	10·61
Ditto . .	Leaves cured with stalk .	2·82	6·08	5·95	1·17	0·205	5·71	20·63	1·47	14·07
Adcock harvested on 27th February 1932.	Leaves cured without stalk.	4·12	5·07	5·05	1·25	0·250	5·02	22·45	1·29	17·44
Adcock harvested on 1st March 1932.	Leaves cured with stalk .	5·37	1·28	2·76	1·18	0·370	3·18	23·01	1·52	15·16
Pusa Type 28 harvested on 18th February 1932.	Leaves cured without stalk.	3·61	1·61	4·21	1·05	0·285	3·68	19·79	1·73	11·41
Ditto . .	Leaves cured with stalk .	4·67	0·83	1·85	0·95	0·315	3·00	22·39	1·58	14·16
Pusa Type 28 harvested on 1st March 1932.	Leaves cured without stalk.	1·46	1·15	2·55	0·92	0·245	3·77	23·12	1·52	15·23
Ditto . .	Leaves cured with stalk .	5·35	1·01	2·36	0·84	0·245	3·43	21·89	1·23	17·82

Potato storage experiment. Mr. P. B. Sanyal continued the experiment on the storage of potatoes. Past and present experiments in potato storage have shown that the rotting of the potato is more dependent on the increase of temperature of the storage places than on the bacterial or fungus infection in the initial stage, for at high temperature potatoes rotted even after effective treatment by fumigation with carbon disulphide or by steeping in copper sulphate solution.

It was further shown that the incidence of rotting in the potato is due to the shortage in oxygen supply to the tissues of the tubers which are stimulated to greater activity at a higher temperature. At lower temperature the diffusion of oxygen through the tissue appears to be sufficient for its respiration but when the temperature rises the rate of diffusion of oxygen cannot keep pace with the increased activity of the tissues and consequently they succumb with the destruction of the vital enzyme such as *catalase* and black heart and black spot appear in the tubers. At this stage, it appears, the bacteria or fungi that are always associated with the tubers, or are present in the atmosphere and storage places, attack the dead tissue and produce heart rot.

The whole problem of storage is, therefore, not to allow the tubers to be stimulated to greater activity during storage. Attention was therefore directed during last year to store potatoes in open pits of different depths in shade where the temperature is somewhat less than that of the atmosphere during summer months. Accordingly, freshly dug out potato tubers were sorted into two sizes, *viz.*, medium and small, and both stored on sand in underground pits of 3′, 2½′ 2′ and 1½′ depth and also, for comparison, on the ground and on a bamboo shelf 3′ above the ground level. Maximum and minimum temperatures of these storage places were recorded daily throughout the storing period. The results of the storage experiment, as stated in Table II, show that in the case of the medium-sized potato the rotting was greatest in the storage pit 3 ft. deep and was less as the depths of the storage pits decreased, though the temperatures of the deeper pits were in no way higher than those of the shallower ones or of the ground. The rotting was more conspicuous during the damp months of August, September and October when the tubers had sprouted than during March to July when the atmosphere was comparatively drier. This clearly shows that a humid atmosphere as is generally met in underground pits during the monsoon is quite unsuitable for storage purposes.

In spite of the higher temperature of the ground, the loss in weight of potato due to rotting was only 3·5 per cent. of the weight of the freshly dug potatoes, while in a 3-ft. deep pit it was as high as 33 per cent. The rotting of potatoes on the bamboo shelves was 9 per cent., this being evidently due to the higher temperature of the shelf than that of the ground. These results, therefore

lead one to infer that, like temperature, moisture also stimulates the tissue activity in the potato, as is evident from the vigorous sprouting of the tubers in the storage pits.

In the case of the small-sized potatoes, the results show that they are less susceptible to temperature and moisture variations and therefore preserve better. This is probably due to their larger surface (weight for weight) which radiates heat more quickly and allows less deposition of moisture on the surface. The loss of small-sized potatoes due to rotting at different storage places varied between 2·8 and 15·2 per cent., while that of the medium ones 3·5 to 33 per cent. The loss due to drying in the case of the smaller tubers was, however, greater than that of the bigger ones, the average being 53·4 and 47·8 per cent. respectively.

Considering the effect of both temperature and moisture, the smaller tubers preserved better than the bigger ones, the loss being 39·3 per cent. and 34·7 per cent. respectively. For seed purpose too, the smaller tubers are preferable and more economical in as much as the requirement for planting the same area is less than half that of the medium ones.

TABLE II.

Storing places	Medium tubers			Small tubers		
	Rotted	Pre-served	Dried	Rotted	Pre-served	Dried
	%	%	%	%	%	%
Pit 3 ft. deep . .	33·05	23·75	43·20	2·78	42·90	54·32
,, 2½ ft. deep . .	19·50	34·96	45·54	15·22	24·40	60·38
,, 2 ft. deep . .	13·30	35·28	51·42	6·94	46·30	46·76
,, 1½ ft. deep . .	16·84	38·38	44·78	8·95	46·45	44·60
Ground . . .	3·47	46·47	50·06	6·03	34·72	59·25
Bamboo shelf 3 ft. high	8·88	32·50	58·62	4·32	40·90	54·78
TOTAL .	17·47	34·75	47·78	7·39	39·27	53·34

The suitability of tubers, from different storing places, for seed purpose was tested by actually sowing them and comparing their germination. The seeds preserved on the ground and those on

bamboo shelf were more sound and gave good and uniform germination. It therefore clearly appears that for seed purpose the potato should be protected from higher temperature as well as from humid atmosphere and there should be sufficient air for their respiration.

Effect of manures on sugarcane juice. The manurial experiment with sugarcane carried out in 1932-33 was designed to see the effect of mineral manures like superphosphate of lime and sulphate of potash on the quality of sugarcane grown with an organic nitrogenous manure as oil-cake. Previous experiments with single artificial and nitrogenous manures showed that the latter when applied to sugarcane increases the yield but the quality of juice from it is inferior. No definite conclusion could be arrived at from some previous experiments carried out in 1929-30 in single 1/20th acre plots. It was therefore decided to lay out the above experiment in four replications for each treatment in a Latin square. The following treatments were adopted for the purpose :— (1) Mustard cake at 100 lb. N per acre, (2) Mustard cake at 100 lb. N. with sulphate of potash at 50 lb. K_2O per acre, (3) Mustard cake at 100 lb. N. with superphosphate of lime at 100 lb. P_2O_5, and (4) Mustard cake at 100 lb. N. *plus* superphosphate of lime at 100 lb. P_2O_5. *plus* sulphate of potash at 50 lb. K_2O. per acre. The area of each plot was 1/40th acre and the space left out between different plots was 6 feet. The manure was applied in two doses, *viz.*, 1/3rd at planting and 2/3rd at the time of earthing. The cane grew well. Periodic analyses of the samples of 10 standing canes drawn at random from each plot were carried out once a month from November to February. The crop was harvested in early February and the yield in maunds per acre worked out for each of the 16 plots. The mean yields for different treatments have statistically no significance.

Experiment on the quick availability of natural indigo for dyeing purpose. Natural indigo from Bihar is prepared into dry cakes for the market and contains about 60 to 65 per cent. indigotin. It can not be used for dyeing purpose readily. The cake has to be ground into a very fine powder, converted into a paste of uniform consistency and reduced by bacterial action or by reducing agents to indigo white (which is soluble in water), before it can be used for dyeing purpose. Finally the cloth dyed in the indigo white, on exposure to atmosphere, is oxidised by the oxygen of the atmosphere, and the indigo white changes to indigo blue. Indigo, whether natural or synthetic, is insoluble in water and it has to be reduced to indigo white, which is soluble, before it can be used for dyeing purpose. For the reduction of indigo to indigo white readily, one of the necessary conditions is to bring the indigo into the form of a paste of uniform consistency, with the particles remaining in suspension in as fine a state as possible or in other words it should be brought into a colloidal state.

With a view to bring the natural product into a readily available form and in a line with the synthetic dye, some preliminary experiments in this laboratory are being carried on on the following lines—

(1) Preparation of indigo paste of definite strength or rather "the standardisation of the paste".

(2) Bringing the indigo paste into a colloidal state by means of chemicals.

(3) To stop fermentation of such paste by means of antiseptics which may not interfere with the strength of colour or with the process of subsequent reduction.

(4) To stop fermentation of such paste by heating or sterilizing it at high temperatures without diminishing the strength of colour.

The work was taken up in January last when no indigo in the form of natural paste was available. Experiments, therefore, so far were carried on with indigo paste prepared from cake powdered into a very fine state and mixed with water of equal weight.

With a view to bring the paste into a colloidal state and to stop fermentation of such paste when kept in sealed tins, treatment with sodium carbonate in the proportion of 1 per cent., 1·5 per cent., 4·5 per cent. of the indigo paste, and subsequent heating of the paste in a water bath for 8 hours at 80°C. were tried. 1 per cent. and 1·5 per cent. sodium carbonate proved totally ineffective, in as much as the paste fermented very badly within four days. Treatment with 4·5 per cent. sodium carbonate, however, stopped fermentation to a good extent, without in any way diminishing the indigotin content or destroying the strength of colour. The addition of sodium carbonate in the proportion of 1·5 per cent. of the weight of paste, and subsequent heating at 120°C. under 1 atmosphere pressure for 40 minutes in an autoclave, proved successful and completely stopped fermentation. The same result was obtained by treatment with 1·5 per cent. sodium carbonate and subsequent heating in an air oven at a temperature of 105°C. for 12 to 15 hours. In none of these latter two treatments, there was any change or destruction of the indigotin. The contents of the sealed tins when opened and examined after three months were found to be unchanged and free from fermentation. The work is in progress.

2. Soils and Fertilizers

Lime requirement of acid soils. Mr. S. Das continued the investigation on the lime requirement of acid soils during the year. Earlier work had confirmed the inadequacy of the existing laboratory methods as a quantitative measure of lime requirement of acid soils. In order to ameliorate acid soil conditions and to collect correlative data for laboratory studies, pot experiments

with an acid soil from Jorhat Experiment Station, Assam, were carried out by adding 1/3, 2/3, 3/3, 2, 3, and 4 times the lime required to bring the pH of the soil to 7. The amount of lime to bring about the neutrality of the soil was found by drawing a titration curve by means of the quinhydrone electrode on adding increasing quantities of standard lime water to a known amount of soil. About two months after the filling of the pots wheat was grown in them.

There was a corresponding series of uncropped pots from which samples of soil were periodically drawn for laboratory studies. pH was determined in these soil samples from time to time. It has been found from the values of pH obtained that a considerable time must elapse after the addition of lime to an acid soil before an equilibrium in soil reaction can be attained. This is in accordance with observations of workers in other parts of the world. It depends not only on the nature and amount of the soil acidity, but also on the kind of liming materials used and prevailing climatic conditions.

In the cropped pots the growth of wheat was not so satisfactory as anticipated, and consequently no definite conclusions can be drawn from the yield. It may, however, be observed that when pH of the soil mixture approaches neutrality or goes beyond 7·0, the wheat plants hardly tend to bear any seed. Apart from the acid character of the Jorhat soil, deficiencies of food materials are perhaps acting as limiting factors for proper plant growth in this soil. In the next crop of *ragi* (*Eleusine coracana*) grown during this monsoon, deficiencies regarding food materials have been eliminated by adding basal dressings of nitrogen, phosphate, and potash to these pots at the rate of 80 lb. of the first two and 40 lb. of the last one per acre. The crop is progressing well at present and its harvest will be watched with interest.

The effect of potash on yield in calcareous soils. The apparent ineffectiveness or even depressing effect of potassic fertilizers has been observed in several field experiments conducted at Pusa. With a view to find out if the ineffectiveness or depression indicated in the field trials at Pusa with potassic fertilizers is due directly to potash or due to some other indirect cause, such as the interaction of the sulphate of potash with the calcium carbonate present in the soil and thereby producing a condition unfavourable to the growth of plants, five small plots of equal area in duplicates as already reported were laid out last year. Three of these plots in duplicates were treated with potassium sulphate and potassium chloride respectively. The fourth one in duplicate had received calcium sulphate and the fifth one in duplicate was left untreated to serve as control. *Eleusine coracana* was sown in all these plots as a *kharif* crop and it was followed by wheat as a *rabi* crop.

As no significant result could be obtained from plots in duplicates, the experiment was extended in October last over 25 newly laid out small plots of equal area, with five replications for each treatment. Wheat was sown in all the 25 plots in November last and the crop harvested in March. It is too early to draw any conclusion from the yield of one season and the experiment has to be continued for several seasons before any definite conclusion can be arrived at.

Limiting factor of phosphate requirements in calcareous soils. It is well known that the growing plant itself possesses more or less power to feed directly on phosphates and that some plants possess specially marked powers. As a result, no common limiting figure for available phosphoric acid can be suggested as given by Dyer (*Jour. Chem. Soc.* 65, 155, 1894) which will be equally applicable to all types of soil, for the figure varies not only with the character of the soil, but also depends on the kinds of crops grown. Consequently, this figure must be worked out for different soils, and it will vary even in the same soil according to the type of crop grown on it from time to time.

The problem becomes further complicated by virtue of the common experience of the ordinary cultivator that different types of soil require different systems of manuring. Although calcareous soils round about Pusa yield extremely low values of available phosphoric acid when measured by ordinary laboratory methods, the action of phosphatic manures on them in actual farm practice is extremely erratic. As for instance, the application of superphosphate alone, more often than not, yields disappointing results, and the best yields are usually obtained when applied in conjunction with heavy organic manures.

Therefore, with a view to discover the limiting factor of phosphate requirements in calcareous soils, two series of pot experiments have been started with a calcareous Pusa soil which, although containing originally 2,100 lb. of total phosphoric acid (P_2O_5) per acre, gives very low values of available phosphate with ordinary analytical methods of the laboratory. In one series nitrogen has been applied at the rate of 100 lb. per acre as sulphate of ammonia and potash (K_2O) at 80 lb. per acre as sulphate of potash, and in the other series dried green manure applied to supply similar amounts of nitrogen and potash per acre. Phosphate has been added in both the series in the form of precipitated calcium phosphate at the rate of 25, 50, 100, 200, 400, 800, and 1,600 lb. P_2O_5 per acre. *Eleusine coracana* has been grown in all the pots. Two corresponding series of uncropped pots have also been started side by side to supply periodically samples of soil for laboratory studies.

Study of soils of tobacco tracts in India. Soils of various tracts in India where tobacco is extensively cultivated vary very widely from one another both in physical and chemical characters. These soils are either black heavy (regur), red laterite, sandy, or fine silt. Some of these are of acid character and some alkaline. With a view to find out common factors, if any, which influence the growth and yield of this crop, a study of both the physical and chemical characters of typical tobacco soils of various parts of India have been taken up. The soils that are under examination for this purpose are those from (*i*) the Kaira District in Northern Gujarat, specially from Nadiad, Anand, Petlad, Borsad and Baroda, from places where either tobacco is grown under unirrigated condition, or grown under irrigation with well waters usually containing a considerable amount of nitrate of potash; (*ii*) Broach District in Southern Gujarat, specially from the *bhatta* lands on the river Nerbudda, where tobacco is grown under unirrigated conditions and without application of manure; (*iii*) the district of Rangpur in Bengal and (*iv*) North Bihar, where tobacco is extensively cultivated under unirrigated conditions. In connection with this work it is intended to obtain other typical soil samples from the districts of Guntur, Trichinopoly and Madura in the Madras Presidency, from the district of Belgaum in Bombay, and from Cooch Bihar and Jalpaiguri, specially from the tracts on both sides of the river Tista, in Bengal.

Nitrifiability and manurial value of apricot seed-cake in soils. In continuation of the experiments reported last year, Mr. S. Das further investigated the nitrogen transformation of the apricot seed-cake in a hill soil from Solon near Simla Hills, containing a fair amount of organic nitrogen, *e.g.*, 0·15 per cent., which is about three times as much as present in Pusa and Kalianpur soils studied last year, but is not so easily nitrified as in the other cases. The cake, however, nitrified more quickly in this soil. As for instance, 58 per cent. nitrogen of the cake is transformed into available forms in four weeks' incubation in it, whereas in Pusa and Kalianpur soils 63 per cent. was transformed in 7 to 8 weeks' time.

On critically examining the curves of nitrate and ammonia formation for the three soils, it is noticed that initially a high proportion of ammonia is formed from the cake in all cases, the immediate depressing effect of which is apparent on the formation of both nitrite and nitrate. This effect dissipates in about two weeks' time in the case of Kalianpur and Solon soils, where the evolution of ammonia is much less than that in Pusa soil, but it persists for a longer period of about four weeks in the latter and retards the formation of nitrate. Boulanger and Massol (*Ann. Inst. Past. 17*, 492—515, 1903; *18*, 181—196, 1904; *Compt. rend. Acad. Sci.* 687, 1905) found that the growth and activity of nitrate bacteria is not injured by the ammonium salt but by free ammonia. This depressing effect appears to have been further accentuated by the

presence of a bitter principle in the cake itself which precludes its use as a cattle food. The chemical examination of the cake revealed the presence of 0·057 per cent. of hydrocyanic acid which is high enough to prove fatal to cattle.

The content of hydrocyanic acid may be attributed to the presence of some cyanogenetic compound in the apricot seed-cake, which may be either a glucoside or an alkaloid. The hydrocyanic acid coupled with free ammonia evolved from the cake, is very likely to adversely effect the normal activities of nitrate and other bacteria in the soil. This point is under further study in the laboratory.

The availability of about 60 per cent. of the nitrogen present in the cake renders it possible as supplying a suitable nitrogenous manure to the soil. To test this point, a set of pot experiments was conducted with a calcareous Pusa soil, where wheat was grown as *rabi* (winter) crop in 1932. Nitrogen was applied to a group of 4 pots for each treatment at the rate of 20, 40, 80, and 100 lb. per acre in the form of apricot seed-cake. The yields of wheat obtained were submitted to Fisher's method of analysis of variance and the results between treatments were found to be significant even for one per cent. level of significance. The application of 80 lb. of nitrogen per acre as apricot seed-cake to Pusa soil gave practically the maximum crop production, 100 lb. of nitrogen per acre, however, yielding a slightly better crop, though not statistically significant. It would thus appear that apricot seed-cake can be successfully used in ordinary farm practice as a suitable nitrogenous manure.

Eleusine coracana has been grown as a *kharif* crop in the above pots where wheat was grown, in order to study the residual effect of the manure, if any. Two fresh series of pot experiments have also been started to evaluate the primary effect of the cake in Kalianpur and Solon soils. *Ragi* has been grown in these pots and the same procedure of manurial treatment as in the case of Pusa soil has been followed.

VI. RESEARCH PROGRAMME FOR 1933-34

(1) *Study of the soils of tobacco tracts in India.* Physical and chemical examination of typical tobacco soils already obtained from North and South Gujarat, from North Bihar, and from Rangpur District in Bengal will be continued. Typical tobacco soils from the districts of Guntur, Trichinopoly and Madura in Madras and from Cooch Bihar and Jalpaiguri in Bengal will be obtained for the purpose of this study.

(2) *Nitrogen balance in Indian soils.* The analysis of soils and crops from the nine permanent manurial plots under different treatments of manuring will be completed and examined for the purpose of constructing a nitrogen balance sheet for the different systems of manuring.

(3) *Lime requirements of acid soils.* Attention will be concentrated on the examination of the cropping power of an acid soil by means of pot experiments after the addition of incremental quantities of lime in proportion to its lime requirement with basal dressings of nitrogen, phosphate, and potash. *Eleusine coracana* has been grown as a *kharif* crop in an acid (Jorhat) soil under varying liming treatments for the purpose. There is also a corresponding series of uncropped pots side by side to supply samples of soil for periodical examination in the laboratory.

(4) *Effect of potash on the yield of crops.* The yield of *kharif* and *rabi* crops from the 25 small experimental plots, in replications of five for each treatment, will be recorded, and will be submitted to Fisher's method of analysis of variance in order to find out the significance of the results. The soils after each harvest of *rabi* crop will be examined for their manurial constituents.

(5) *Limiting factor of phosphate requirements in calcareous soils.* With a view to discover the limiting factor of phosphate requirement in calcareous soils two series of pot experiments have been instituted with a calcareous (Pusa) soil to which precipitated calcium phosphate has been added in amounts varying from 25 to 1,600 lb. of P_2O_5 per acre. In one series inorganic nitrogen as ammonium sulphate and in the other organic nitrogen as dried green manure at the rate of 100 lb. nitrogen per acre have been applied in order to study at the same time the effect of mineral and organic nitrogenous manures on phosphate manuring in these soils.

6. *Nitrifiability and manurial value of apricot seed-cake in soils.* An investigation into the manurial value of the cake will be made in Solon and Kalianpur soils by means of pot experiments with *Eleusine coracana* as the *kharif* crop. The residual effect of the manure, if any, will be similarly studied by pot experiments with the Pusa soil where the cake was applied to grow wheat during the last winter.

7. *Effect of manures on sugarcane juice.* The effect of oil-cake (mustard cake) alone, and in combination with either superphosphate of lime or sulphate of potash or both, will be further studied on sugarcane grown in Latin square plots in replications of four for each treatment. The canes will be periodically analysed from November till harvest, when the yield will be recorded and the fibre in cane determined, in addition to ordinary juice analysis, in order to get an idea of the total sugar in each plot.

8. *Storage of potatoes.* Experiments on the storage of potatoes will be continued in a dry and cool place. Laboratory experiments will be conducted to find out if the beginning of heat rot in potato is due to bacterial or enzymatic action.

9. *Standardisation of indigo paste and its prevention from fermentation.* Experiments in this connection so far have been carried with natural dry indigo cake converted into paste. Natural

indigo paste as available immediately after *mahai* will be brought to and maintained at a definite concentration in respect of indigotin content. Various chemical antiseptics and methods of sterilisation by heat, which should not destroy the indigotin or interfere with its subsequent reduction to indigo white, will be tried in order to prevent fermentation of the standardised paste when kept in sealed tins.

VII. PUBLICATIONS

Das, S. . . . . The Effect of Gypsum on Calcareous Soils. *Agri. and Livestock in India*, Vol. III, Pt. II, March 1933.

Hossain, M.A. . . . Disintegration of Bones by Alkali method and their use as Fertilizers. *Agri. and Livestock in India*, Vol. III, Pt. II, March 1933.

REPORT OF THE PHYSIOLOGICAL CHEMIST

(F. J. WARTH, D. Sc. (Bir.), B. Sc. (Lond.), I. A. S.

I. CHARGE

Mr. A. Viswanatha Iyer held charge of the Section until the 9th November, 1932, on which date I took over charge.

II. LABORATORY WORK

The following is a list of analyses completed during the year :

Complete analyses—		
1. Fodders	44	
2. Fæces	80	
		124
Dry matter in fæces, urine, fodders, etc.		2,229
Single nitrogen determinations in fresh fæces, fodders, urine, etc.		647
Mineral analyses of urine, fodders, fæces, etc.		258
Complete analyses of urine		97
Miscellaneous analyses		255
Total		3,610

III. RESEARCH WORK OF THE SECTION

1. Experiments on the nutrition of growing animals

An experiment on mineral feeding to growing animals has been carried out. Two groups consisting chiefly of 18 months old heifers were given identical rations in every respect, except that one group received a mineral supplement and the other group received no supplement. At the end of twelve weeks there was no visible difference between the two groups. In condition they were similar, food consumption and live-weight increase for the two groups were more or less the same.

Average daily consumption (in kilogrammes) per head and live-weight (in pounds)

Week	Group "A" (mineral supplement)				Group "B" (no mineral supplement)			
	Consumption			Live weight	Consumption			Live weight
	Roughage	Concentrate	Total		Roughage	Concentrate	Total	
1	3·916	1·243	5·159	420	4·273	1·240	5·513	440
2	4·190	1·293	5·483	426	4·470	1·291	5·761	447
3	4·121	1·232	5·353	436	4·211	1·222	5·433	454
4	4·148	1·246	5·394	443	4·332	1·269	5·601	461
5	4·501	1·250	5·751	449	4·701	1·268	5·969	469
6	4·559	1·273	5·832	..	4·898	1·277	6·175	..
7	4·559	1·273	5·832	465	4·898	1·277	6·175	480
8	4·573	1·289	5·862	470	4·878	1·297	6·175	487
9	4·578	1·296	5·874	477	4·909	1·306	6·215	493
10	4·328	1·307	5·635	481	4·901	1·332	6·233	496
11	4·371	1·308	5·679	487	4·821	1·315	6·136	503
12	4·520	1·314	5·834	496	4·979	1·327	6·306	512

The figures show that both groups consumed their rations with regularity and made regular progress in live-weight increase.

The results for the two groups are almost identical in every respect, and it must be concluded that the mineral supplement had no perceptible effect either on growth or condition.

It may be noted that the food consumption was unusually satisfactory amounting to 27·2 and 27·7 lb. dry matter per 1,000 lb. live-weight for groups A and B respectively.

The live-weight increase, 76 lb. for group A and 72 lb. for group B, is also very satisfactory.

This ration has given good results in every respect and does not need a mineral supplement.

Hence 0·73 per cent. Ca_0 and 0·47 per cent. $P_2 0_5$ in basal ration suffice for normal growth. Actual assimilation of minerals from the two rations was determined during digestion trials. The following results were obtained :—

Assimilation of minerals average per day in grams

	Group "A"		Group "B"	
	P_2O_5	CaO	P_2O_5	CaO
Intake	32·13	50·84	33·26	54·94
Outgo	25·96	44·15	28·03	45·17
Balance	+6·17	+6·69	+5·23	+9·77

From the above it may be noted that there is no appreciable difference in the assimilation of CaO and $P_2 O_5$ between the two groups. Blood of animals from the two groups was also tested for Ca and P, and it was found that, except for slight individual variations, the two groups showed no difference.

2. Experiments on milk production

As mentioned in the last report, an experiment on high and low protein rationing to cows has been undertaken in collaboration with the Dairy Section. After certain set-backs the work is now proceeding satisfactorily. It is impossible to draw definite conclusions at this stage. It appears, however, that the composition of the milk is not perceptibly affected by the difference in feeding practice. Some typical figures bearing on this point are given in the accompanying table.

Composition of milk with high and medium protein ration

	Total solids per cent.		Ash per cent.		Protein per cent.		Fat per cent.		Sugar per cent.	
	High	Medium	High	Medium	High	Medium	High	Medium	High	Medium
7-3-1933	13·020	12·366	0·695	0·744	2·904	2·872	4·5	4·1	4·8	4·38
2-4-1933	12·698	12·260	0·679	0·737	2·888	3·015	4·5	4·2	4·55	4·5
6-6-1933	12·389	12·493	0·703	0·750	3·090	3·261	4·25	4·5	4·6	4·4

There is an indication, which requires confirmation, that the higher protein ration prolongs the lactation period slightly. On the other hand, with the high protein unfavourable effects on the cows are suspected. It is evident that the experiment must be continued for a long time to make the conclusions clear on these points.

3. Indian coarse fodders

This work has been continued on the lines indicated in previous reports. Tests are in progress at present with some typical Mysore hay samples. The effect of the stage of maturity upon composition and digestibility is being studied with this material.

Tests with certain *juar* (sorghum) samples have been completed. In this case two stages of development, representing respectively the prime and the ripe crop, were examined. In each series feeding experiments were carried out both with the fresh fodder as it came in from the field and with identical material converted into hay. Some very interesting results have been obtained in this work. The accompanying table shows that, in every case, conversion into hay has led to a notable increase in the " crude fibre " fraction and a corresponding serious lowering of digestibility of the carbohydrates.

	Crude fibre		Soluble carbohydrates	
	Per cent. Crude fibre	Digestibility co-efficient	Per cent. Soluble carbohydrates	Digestibility co-efficient
Prime *juar* . . .	35·3	61·9	48·9	62·0
Prime hay . . .	39·4	60·6	42·7	43·7
Ripe *juar* . . .	36·9	61·8	49·9	57·6
Ripe hay . . .	40·9	57·4	45·5	44·2

Similar effects have been obtained by the Nutrition Section in earlier experiments. The data relating to *juar* are being selected for publication.

A chemical enquiry may also be referred to appropriately here. Experiments have been undertaken to compare the carbohydrates of four typical fodders, *viz.*, rice straw, *ragi* (*E. coracana*) straw, *juar* straw and hay. The question is whether marked physical differences exist between the carbohydrates of such distinct products possessing distinct digestibility co-efficients.

4. Experiments with legume hays

This is a new line of work undertaken by the Nutrition Section. There is no doubt that legume hays are very valuable as cattle food. Very little work has been done on this subject in India. The present experiments are of a tentative nature to study the preparation of such hays, to determine their digestibility and to observe their effect on the nitrogen balance. In all, six types of hay were made. Of these, only four, *viz.*, groundnut hay, cowpeas hay, cluster-beans hay and soya-bean hay were successful. All will be made again this year and with the experience that has been gained and the modifications that have been introduced both products are confidently expected. Emphasis is laid on this enquiry because it is most desirable to encourage the production and utilization of legumes for animal nutrition in India.

5. Mineral requirements of cattle

Last year an experiment was reported and published in which the minerals provided by two fodders, *viz.*, *ragi* straw and mature hay, were compared, using mature bullocks for the test. This year a similar experiment has been completed in which rice straw and *juar* hay have been tested and compared. The method of experimentation was exactly the same as that employed in the former series of tests. The two fodders were first tested without a mineral supplement. This was followed by a period of mineral feeding. Finally there was a period in which mineral and green grass supplements were given. The intention in the last test was to determine whether green grass vitamins could bring about further mineral assimilation. The experimental work and the analyses have been completed but the data are not yet fully worked out. The following table shows the average results obtained for each period.

	Rice straw		*Juar* hay	
	P_2O_5	CaO	P_2O_5	CaO
1st period . . .	+0·09	—2·42	+3·12	+2·61
2nd period . . .	+4·41	+0·74	+2·06	+2·72
3rd period . . .	+3·25	+4·26	+2·12	+5·01

From the above figures it may be concluded that rice straw provides just enough P_2O_5 but not enough lime. In the second period when the ration was supplemented by calcium phosphate

there was appreciable assimilation of lime and phosphoric acid and both showed a positive balance. During the third period there was no marked assimilation of P_2O_5 but an increased assimilation of lime is visible.

With regard to *juar* hay, as there was a sufficiency of both lime and phosphoric acid, there was not any marked difference in the assimilation of lime and phosphoric acid during the first two periods, but an increased assimilation of lime was noticeable in the third period. This emphasizes the previous observation that a mineral supplement has no appreciable effect in cases where there is enough present in the fodders themselves.

6. Indian pasture grasses

As explained in the previous reports, this work is intended to give comparative values of the mineral composition of grasses grown on selected typical soils in various parts of India. Some of the latest results are shown in the accompanying table.

Percentage mineral composition of grasses grown at different centres

	Stage of maturity	Pusa (Bihar)			Poona (Bombay)			Sabour (Bihar)				Bangalore (Mysore)		
		Before flowering	In full bloom	Dead ripe	Before flowering	In full bloom	Dead ripe	Before flowering	In full bloom	Dead ripe		Before flowering	In full bloom	Dead ripe
Andropagon contortus	Ash.	9·27	9·65	8·14	10·86	12·00	10·93	11·43	9·29			12·57	10·93	8·59
	Ash soluble in Hcl	4·00	3·72	2·91	3·94	3·76	2·02	3·62	2·60			8·18	7·25	3·67
	P_2O_5	0·256	0·218	0·228	0·164	0·185	0·059	0·331	0·402			0·628	0·428	0·188
	CaO	0·649	0·589	0·835	0·363	0·389	0·345	0·530	0·525			0·603	0·558	0·403
	MgO	0·280	0·315	0·250	0·305	0·340	0·240	0·220	0·282			0·407	0·417	0·295
	Na_2O	0·315	0·288	0·381	0·282	0·167	0·392	0·213	0·318			0·168	0·273	0·225
	K_2O	1·863	1·307	0·742	1·526	1·337	0·451	1·240	1·586			3·861	3·206	1·511
	Crude Protein	4·489	4·530	3·163	6·370	4·975	2·730	3·620	5·988			15·100	10·925	4·863
Andropogon annulatus	Ash	13·37			11·10	13·37	11·39	11·99	7·76			11·60	12·01	8·89
	Ash soluble in Hcl	8·54			2·99	3·35	2·97	3·32	3·43			7·02	5·08	4·58
	P_2O_5	0·529			0·214	0·269	0·176	0·502	0·437			0·508	0·474	0·302
	CaO	1·205			0·459	0·418	0·390	0·807	0·631			0·876	0·762	0·436
	MgO	0·324			0·249	0·282	0·320	0·204	0·213			0·377	0·269	0·426
	Na_2O	1·046	No sample.	No sample.	0·331	0·247	0·264	0·207	0·151	No sample.		0·548	0·529	1·486
	K_2O	4·078			1·136	0·990	1·017	0·907	0·813			3·058	1·826	1·553
	Crude Protein	9·037			5·276	7·944	5·706	3·469	3·016			14·681	11·893	8·275
Pennisetum Cenchroides	Ash	21·21	12·50	12·63	4·85	23·73		13·95	12·84	14·17		13·49	11·72	9·22
	Ash soluble in Hcl	15·58	8·54	6·53	4·63	5·25		5·33	6·01	6·29		9·20	7·77	5·19
	P_2O_5	0·537	0·419	0·399	0·226	0·206		0·765	0·575	0·815		0·671	0·501	0·306
	CaO	1·266	0·628	0·770	0·500	0·597		0·486	0·552	0·555		0·432	0·436	0·480
	MgO	0·541	0·375	0·393	0·611	0·722		0·167	0·320	0·276		0·368	0·432	0·451
	Na_2O	0·594	1·166	1·421	1·126	1·021		1·275	1·192	1·112		1·350	1·583	1·173
	K_2O	8·935	3·985	2·558	0·662	0·608		1·925	3·305	2·612		3·887	3·050	1·620
	Crude Protein	10·763	9·175	6·281	14·213	10·456		5·823	9·231	6·175		14·369	11·913	7·056

No sample. — Dub C. dactylon hay.

Looking into the figures it is seen that different varieties of grasses grown at the same place show marked differences in their composition, as also the same variety grown at different places. But looking at the figures of the three varieties grown at Bangalore, this is not borne out by the figures evidently due to other factors exerting their influence. Another observation is the known fact that the mineral contents vary with the stage of maturity, the dead ripe stage producing very poor quality. More data are being collected and when these are completed, they will form the subject of a more detailed publication.

While the main question in this work relates to minerals subsidiary information on the characteristics of some pure species of grass is being collected incidentally. For example, it has been found that the protein content is a specific character. The figures given in the table illustrate this fact very clearly.

7. Experiments with sheep

The work in hand at present is concerned with the influence of rationing on wool production. The experiments are in a preliminary stage and it is not possible to give any figures.

8. Physiological studies

Work on hippuric acid, phenols, and acid base balance, as outlined in previous reports, has been continued. Work on blood analysis has made considerable progress. The procedures have been improved and standardised and some data have been collected. Comparing *ragi* straw and mature *juar* rations the following figures for blood Ca and P were obtained from two animals on these two rations.

	Gopal		Jaya		
	P	Ca	P	Ca	In mg. per 100 c. c. plasma
Ragi straw . . .	3·79	9·95	3·90	9·99	
Mature *juar* . .	5·23	9·40	5·77	8·60	

Juar evidently gives higher blood P and calcium about the same for the two rations.

In a mineral feeding experiment with calves considerable individual variations of blood calcium and phosphorus were noted. With such animals it will probably be necessary to carry out tests by reversal of rationing.

Glycuronic acid excretion. It has been found that conjugated glycuronic acid is present in all urine samples of our cattle and sheep. The quantity varies very materially according to the nature of the fodder. A recent test has proved clearly that glycuronic acid conjugation is not concerned with a substance which can be detoxicated alternatively by sulphuric acid. Two

sheep were fed the same ration of cake, grass and hay. One of these animals received a sulphate supplement. The urine showed the following characteristics :—

	Sheep 1	Sheep 2
Glycuronic acid (yield of Furfurol in grm.) . . .	0·138	0·156
Sulphate excretion (grm. $BaSO_4$ per day) Total . .	5·00	1·80
Sulphate excretion (grm. $BaSO_4$ per day) Free . .	3·00	0·00

That is to say, even when the sulphate is very greatly increased there is little change in the glycuronic acid output.

Sulphur and sulphate balance experiments. Following up work published last year (*Indian Journal of Veterinary Science and Animal Husbandry*, Volume II, Part III, September 1932), it has been shown again that the sulphur balance is favourably influenced by injection of inorganic sulphate. Of four sheep fed identically in other respects, two received a supplement of sodium sulphate and the other two received no supplement. The sulphur balances for the four animals were found to be as follows :—

	Sulphate supplement		No supplement	
	No. 1	No. 2	No. 3	No. 4
Sulphur balance as grm. $BaSO_4$ per day.	+0·437	+0·316	—0·146	—0·065

These are striking and very significant figures. The work is proceeding.

IV. CO-OPERATION WITH OTHER DEPARTMENTS

As usual, grasses, hays and crops raised by the Military Farms Department are being tested.

With the Mysore Department, co-operation work on legume hay and pasture grasses is proceeding and joint work on blood analysis of typical animals has been arranged.

V. LECTURES TO STUDENTS

As usual, lectures on chemistry and animal nutrition have been provided for the Dairy Diploma students.

VI. PUBLICATIONS

The following papers were published during the year under report :—

1. Sulphur and Sulphate Balance Experiments with Cattle, by F. J. Warth. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part III, September 1932.
2. The Quantitative Production of Benzoic acid and Phenols in the Animal System, by F. J. Warth and N. C. Das Gupta. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part III, September 1932.

3. The Conjugation of Benzoic Acid by Indian Cattle, by N. C. Das Gupta. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Pt. III. September 1932.
4. An Experiment to determine the effect of Hippuric Acid excretion on the Nitrogen Balance, by F. J. Warth and N. C. Das Gupta. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part III, September 1932.
5. The Influence of Urinary Reaction on excretion of Lime and Magnesia, by N. Krishna Ayyar. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part III, September 1932.
6. An Experiment on Mineral Assimilation from two typical Fodders, by F. J. Warth, A. Viswanatha Iyer and N. Krishna Ayyar. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part IV, December 1932.
7. A Preliminary Experiment on the digestion of fats by bullocks, by P. A. Seshan. *Ind. Jour. Vet. Sc. and Animal Husb.*, Vol. II, Part IV, December 1932.
8. Silage Investigations at Bangalore, III—Effect of the stage of maturity on the Ensilage of *Juar*, by T. S. Krishnan. *Agri. and Livestock in India*, Vol. II, Part V, September 1932.
9. Silage Investigations at Bangalore, IV—Ensilage of *Juar* Straw, by T. S. Krishnan. *Agri. and Livestock in India*, Vol. II, Part VI, November 1932.
10. Relative merits of high and low Silage Feeding to Cows in Milk, by the Post-graduate students. *Agri. and Livestock in India*, Vol. III, Part II, March 1933.

VII. PROGRAMME OF WORK FOR 1933-34

Major subjects

1. Experiments in the nutrition of growing animals.

2. Experiments on milk production, including mineral assimilation.

3. A study of Indian coarse fodders, including maturing tests.

4. Indian pasture grasses: a survey of their mineral composition.

5. Blood analysis.

6. Preliminary respiration work.

7. Sheep-feeding experiments.

8. Physiological studies.

Minor subjects

1. A study of the chemical methods employed in the above enquiries.

2. Preliminary experiments for the initiation of work on other aspects of nutrition.

REPORT OF THE IMPERIAL MYCOLOGIST

(W. McRAE, M.A., D. Sc., F. L. S.)

(1) MYCOLOGICAL SECTION, PUSA

I. CHARGE

Dr. M. Mitra was in charge of the Section until the 29th December 1932, when Dr. McRae resumed duty as Imperial Mycologist and Director on return from officiating as Agricultural Expert to the Imperial Council of Agricultural Research. Assistant L. S. Subramaniam was appointed Assistant Sugarcane Mycologist with effect from 23rd June 1933, under the scheme for research in mosaic and other diseases of sugarcane financed by the Imperial Council of Agricultural Research.

II. TRAINING

An Agricultural Overseer of the Bihar and Orissa Department of Agriculture received training on diseases of the potato crop and methods of controlling them. Mr. G. S. Kulkarni, Special Cotton Mycologist, Dharwar, worked in the section for three months and help was rendered to him in the writing up of his cotton wilt report.

III. DISEASES OF PLANTS

(*i*) Pigeon-pea

Fusarium vasinfectum on *Cajanus indicus*. The resistant capacity of Type 80 was again tested in the fifteen Punjab permanent manurial plots (A series), and 22 deaths occurred as compared with three during the last year, while during 1928-29 when ordinary mixed farm seed was sown in the plots the wilted plants numbered 5,656. A paper entitled "Influence of Manures on the Wilt Disease of *Cajanus indicus*" is being published as Scientific Monograph No. 7 of the Imperial Council of Agricultural Research.

(*ii*) Sugarcane

Mosaic disease. The whole area of fifty-five acres under sugarcane in the farm was rogued and the varieties affected with

the disease, together with the area under cultivation, as compared with that during the previous three years, were as follows :—

Variety.	1929-30		1930-31		1931-32		1932-33	
	Area in acres	Percentage of infection	Area in acres	Percentage of infection	Area in acres	Percentage of infection	Area in acres	Percentage of infection
Co. 210 .	13·0	0·005	8·2	*Nil*	10·44	0·01	16·27	0·017
Co. 213 .	6·7	0·13	8·	0·091	9·77	0·05	14·12	0·093
Co. 281 .	..	..	..	..	2·71	0·006	12·48	0·2
Co. 299 .	2·04	0·03	0·6	0·02	1·39	0·01	2·57	0·1
Co. 302 .	..	..	0·6	0·03	..	..	..	..
Co. 303 .	..	..	1·25	0·005	0·85	0·01	..	..
Co. 313 .	0·31	0·002	..	..	..	..	3·06	0·005

In all there were 14 varieties under field trial and 43 varieties in the nursery. All these varieties, except those mentioned above, were free from the disease during the year.

In the experiment laid down in February 1933, to test the natural spread of mosaic disease where a row of each of the 43 varieties alternated with a row of Co. 213 mosaic-infected cane, all the varieties tested remained free from infection up to the end of June. The varieties tested were :—Saretha, Chunnee, Co. 210, 213, 214, 281, 285, 290, 299, 300, 301, 302, 303, 312, 313, 316, 317, 318, 319, 327, 331, 332, 337, 338, 339, 340, 341, 342, 343, 344, 345, 346, 347, 348, 349, 350, 351, 352, 353, 355, 356, 357, Tuco 393, Tuco 472 and P. O. J. 2878.

Tonnage experiments. A paper entitled "Effect of Mosaic on the tonnage and the juice of sugarcane in Pusa. Part II", giving the result of the last year's investigation, was published, and the experiment was continued. Thirty-six plots each 5 by 56 yards of Co. 213 were laid down in adjacent pairs, half of them with mosaic-free and half with mosaic cane in the order mosaic-free, mosaic, mosaic, mosaic-free and so on. The area was good and suitable for growing sugarcane. Great care was taken to select the canes for planting. A small amount of infection spread to the mosaic-free plots, and altogether seven clumps were found to have the disease in six plots. Thus the mosaic-free plots were substantially free from infection as such small numbers have a quite inappreciable effect on the weight of the stripped cane. This small spread to healthy cane in plots in such close juxtaposition to mosaic infected cane as they are, indicates how few and how inactive insects were during the season in spreading the disease.

The mean percentage of infection with insects was slightly more than that of last year and as follows :—

Insects	Mosaic-free	Mosaic
Top shoot borers (*Scirpophaga nivella* Fabr.)—		
Early attack	10·9	10·5
Late attack	26·02	26·7
Stem-borers (*Argyria sticticraspis* Hmpn. *Diatraea venosata* Wlk., *Chilo zonellus* Swinh.)	4·35	4·36
Root-borer (*Emmalocera depressella* Swinh.)	9·29	9·2
Termite	9·5	8·58

The mean difference in each case is small and has no statistical significance. Whatever loss was caused by these insects was so evenly distributed that it did not have any effect on the difference of the mean tonnage of the plots. No damage was done to the canes either by fungi or by animals. Before harvesting the cane it was noticed that the stand of cane at the extreme end of the block was much thinner than in the rest of the block. Termites in the latter part of the growing season had been more active there. A row of low trees had been cut out in the previous season along the roads a few yards from the sides of the block, and experience has shown that the termites are liable to be more numerous till the roots decay and it may be considered that the two end plots, both mosaic-free, did not show the relative difference in yield between their corresponding mosaic plots that might be due to the presence of the disease. It was considered that the unequal damage caused by white ants that had destroyed the cane was likely to make the difference due to disease. It was accordingly decided that leaving the two end pairs of plots out of account would provide a set of sixteen pairs that would be a truer representation of the facts. After removing cane to eliminate edge effect the plots were five by fifty yards and the yield of stripped cane in maunds (82·28 lb.) was as follows :—

Weight in maunds (82·28 lb.) of stripped cane of Co. 213

Mosaic-free	Mosaic	Mosaic-free	Mosaic
38·26	38·58	47·26	52·41
41·70	44·20	52·92	47·84
47·72	45·69	52·45	49·90
45·53	40·53	50·53	48·99
42·39	40·31	50·30	51·42
47·98	49·90	47·73	45·55
46·16	49·43	42·85	45·16
47·63	46·98	41·00	41·86
Mean 46·40	46·17		
Difference 0·23			

Samples from all plots were analysed by the Imperial Agricultural Chemist and the details are given below

Plot Nos.		Weight of cane in lb.		Weight of juice in lb.		Percentage weight of juice to cane		Brix corrected		Sucrose per cent.		Glucose per cent.		Purity per cent.	
F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.
4	3	301	322	201	213	66·7	66·3	16·59	17·77	12·68	14·24	1·04	0·85	76·44	80·15
5	6	261	344	173	210	66·3	61·1	17·73	17·69	14·60	14·39	0·86	0·78	82·32	81·32
8	7	419	431	315	298	75·2	63·4	17·59	17·37	14·20	13·87	0·86	0·86	80·71	79·82
9	10	380	377	279	272	73·5	71·9	17·76	17·75	14·34	14·45	0·85	0·78	80·73	81·39
12	11	386	336	282	223	72·9	66·4	18·37	17·90	14·90	14·41	0·84	0·81	81·10	80·52
13	14	408	430	278	297	68·6	69·1	16·93	17·43	13·18	14·08	1·06	0·83	77·83	80·74
16	15	483	456	333	276	68·9	60·5	17·71	17·74	14·22	14·33	0·95	0·93	80·29	80·75
17	18	407	386	279	254	68·7	65·9	17·46	17·86	13·94	14·60	0·99	0·84	79·85	81·74
20	19	346	427	237	294	68·4	68·8	17·69	17·34	14·20	13·73	0·95	0·92	80·25	79·18
21	22	420	391	292	279	69·5	71·1	17·62	18·30	14·08	14·97	1·04	0·85	79·92	81·81
24	23	367	353	252	237	68·6	67·3	18·07	18·33	14·58	14·80	1·06	0·91	80·67	80·75
25	26	397	374	274	258	69·0	68·9	17·81	17·03	14·22	13·33	1·04	1·06	79·86	78·37
28	27	422	379	293	261	69·4	68·9	17·01	16·36	13·31	12·32	1·16	1·16	78·24	75·29
29	30	439	311	311	212	70·8	68·1	17·36	18·50	13·27	15·01	1·17	0·86	76·46	81·12
32	31	364	405	248	283	68·1	69·7	18·53	18·39	15·23	14·94	0·74	0·79	82·16	81·24
33	34	370	377	256	252	69·2	66·9	18·91	17·93	15·64	14·40	0·67	0·93	82·71	80·30
Mean		385·6	381	268·9	257·4	69·61	67·14	17·696	17·73	14·16	14·24	0·95	0·88	79·97	80·28
Difference		—4·6		—11·5		—2·47		+0·034		+0·08		—0·07		+0·31	

The statistical figures calculated by "Student's" method " to determine the significance of the difference in yield between the series of pairs of plots are summarised below :—

Co. 213	Mean difference	Standard deviation	Mean difference / Standard deviation	Odds
Cane yield	0·23	2·8	0·08	0
Juice	11·5	38·0	0·3	6:1
Percentage juice to cane . .	2·47	3·64	0·67	77:1
Calculated juice per plot . .	1·3	2·6	0·5	27:1
Brix	0·034	0·51	0·06	0
Sucrose	0·08	0·84	0·1	2:1
Glucose	0·07	0·12	0·58	36:1
Purity	0·31	2·1	0·15	2:1

Thus the difference in the percentage of juice to cane, the calculated juice to cane and the glucose are alone statistically significant. This year then in the mosaic plots the weight of the stripped cane and the quality of the juice had not deteriorated, indeed there was slightly less glucose. However, four per cent. less juice was extracted from the cane in the mosaic plots.

Survey. In July 1932, an attempt was made to get a better appreciation of the intensity of mosaic infection in the cane fields of North Bihar. The Deputy Director of Agriculture, North Bihar Range, co-operated in the survey by allowing three overseers of his staff to work with three assistants of the Mycological Section at Pusa and by planning the details of the tour. The method of sampling was to take narrow strips in different fields in each of the selected sixty-five localities and to record the total number of clumps of cane and the number of clumps infected, in order to get the percentage of infection. On looking at the map on which the places examined are plotted the sample as a whole presents a fairly representative picture of the position in North Bihar with regard to the intensity of mosaic disease. The

summary of the record for this and the two previous seasons in which a survey was made is as follows :—

Variety	1927			1931			1932		
	Area of strips examined	No. of localities	Percentage infection	Area of strips examined	No. of localities	Percentage infection	Area of strips examined	No. of localities	Percentage infection
Co. 213 .	39·5	6	0·03	13·6	8	0·3	50·37	47	0·58
Co. 210 . .	5·0	1	0·5	1·6	5	0·96	26·37	27	0·09
Co. 205 . .	6·7	4	15·00	1·0	4	9·0	0·13	1	0·7
Co. 285 Not grown on a field scale.							5·5	5	0·12

The increase in the percentage of mosaic in Co. 213 in 1932 is due to high infection in three localities in the Siwan Sub-division consisting of 1·76 acres with 12 per cent. infection. The Coimbatore canes have almost completely ousted the local variety in the area examined but in two localities (0·64 acre) the latter was found to be wholly infected with mosaic disease.

Yellowing of canes. The yellowing of canes mentioned in the last year's report appeared again in the Pusa and the Sepaya Farms and also in many other places during July and August but in most places plants recovered later on. The different fungi isolated from the decaying roots proved to be saprophytic. Application of calcium sulphate, potassium sulphate and uspulun had some effect in the recovery of plants from yellowing. The plants responded to potassium sulphate more readily. Further experiments are being conducted by the Imperial Agricultural Bacteriologist.

Top-rot. The species of *Fusarium* causing top-rot has been definitely identified as *Fusarium moniliforme* Shel.; its parasitism has been established, the top-rot and the other typical symptoms have been reproduced artificially. The disease is caused by the infection of the growing point in the early stages of the growth of the cane. In cases where infection takes place late the fungus is kept in check, the plants grow normally, and the effect of the fungus is only seen in the shortening of the leaf

blades especially at the ends of the shoots. The disease was noticed in the following cane varieties at Pusa :—Co. 210, 213, 214, 285, 299, 303, 313, 322, 331, 337, 339, 344, and at Dacca, Co. 213, 223, 281, 361, 364, 386, 403, 407 and 417.

Red-rot. An out-break of red-rot was observed on Co. 210 in the latter part of November 1932 in Pusa and surrounding places. In one place where Co. 213 was growing next to Co. 210 or mixed with Co. 210, Co. 213 was free from the disease, only Co. 210 was found attacked and the infection was up to 40 per cent. In Pusa in Co. 210 the disease had just begun to enter the stem through the buds and as a precautionary measure only the top one-third of the cane was planted and up to the end of June 1933, the disease has not appeared in any of the plots. It is presumed that infection had taken place from spores of *Colletotrichum falcatum* found on the mid-rib of leaves after being washed down by rains to the nodes. This is an interesting occurrence, for the cane at Pusa has been free from red-rot for six years. Several isolations of *Colletotrichum falcatum* have been made from the mid-rib of the leaf and the stem of various varieties of sugarcane grown in different localities in India with a view to determine the number of physiological strains in this species.

H. Sacchari. Dr. Mitra's study of *Helminthosporium* on sugarcane was continued. Three more strains of *Helminthosporium* were isolated, one from Allahabad and two from Arbhavi (Bombay) and are being compared with *H. Sacchari* Butl. from which they differ in cultural characters to some extent but the spore morphology shows that they are closely allied and may only be different strains. The two strains from Arbhavi were isolated from different spots of similar appearance but one was highly sporulating with longer spores as compared to the other. This highly sporulating strain resembles a saltant isolated from *H. sacchari* to a great extent and occurred not only in nature but also appeared as a saltant from a single spore culture of the other Arbhavi strain. The pathogenicity of these three isolates is being tested and preliminary tests show that one is more vigorous than the other. A large number of saltants were grown from generation to generation. Several of these reverted to the parent form, while many bred true and formed sclerotial bodies. A large number of spore measurements are being made for comparison and the pathogenicity of all the saltants is being tested.

(*iii*) Hibiscus sabdariffa

Stem rot. This disease due to *Sclerotinia sclerotiorum* (Lib.) de Bary again appeared in the first week of January in a more virulent form. Plants sown in a plot highly infested, artificially, with sclerotia and mycelium, did not show the presence of the

fungus until December. When the disease appeared, plants were again examined by Dr. Mundkur and it was observed that the parasite was localised in the upper part of the stem and could not be traced down to the soil. The disease also appeared in plants growing in sterilized soil in pots, and it thus became manifest that the infection was air-borne. The finger-like processes referred to last year developed apothecia both in moist saw dust and in culture media. For apothecial development an air temperature of below 23°C. seemed to be necessary and this occurs in the last week of December and in January. The appearance of the disease in January together with the fact that the parasite develops the ascospore stage only in the cold weather showed that infection is mainly due to these spores. Varieties maturing by the time the disease appears would automatically escape infection and attempts are being made to see if the type under study can be made to set seed a little earlier.

(*iv*) Rice

Sclerotial diseases. In plots artificially infected by mixing with the surface soil a large number of sclerotia of *Sclerotium oryzae* Catt. paddy plants were transplanted at the proper time. There was a good deal of damage to the crop due to white ants and typical sclerotial disease was not observed. Studies on the large number of cultures of the sclerotial fungi attacking rice have been continued by Dr. Mundkur. It looks as though there are more than one species, that there is physiologic specialization and that there are geographical strains. Careful observations on the manner and mode of growth on nutrient media have been recorded and sclerotial measurements made for statistical examination of data. Sclerotial measurements of parent-progeny have shown, after biometrical examination, that they are reliable guides in the separation of physiologic forms and of species. Using malachite green as a differential dye, it has been found possible also to distinguish species which are otherwise difficult to diagnose.

Sterility. A number of rice plants showing symptoms of sterility were noticed on the Cuttack Farm in scattered patches. An examination of diseased plants showed the presence of some mycelium at the nodes and a species of *Cephalosporium* was isolated. Infection experiments to test the pathogenicity of this fungus are in progress.

(*v*) Piper betel

The temperature relationship study of six strains of *Phytophthora*, isolated from betel-vine, was made and was compared with five other known species of *Phytophthora*. A series of inoculations and cross-inoculation experiments was carried out and the previous year's observations were confirmed. To control

'foot-rot' caused by *Rhizoctonia solani* and *Sclerotium rolfsii*, Kerol treatment (0·07 per cent.) was repeated and promising results confirming last year's were obtained. Phenyl in 1·0 per cent. and 0·5 per cent. strength was also tried and this gave promising results. No deaths took place in pots infected with *S. rolfsii* or *R. solani* where Kerol or phenyl was applied.

(*vi*) Crotalaria juncea

Wilt disease. During last two years a wilt disease of sann-hemp has been noticed to do considerable damage and an estimate made during the year under report showed that in one particular plot the disease was up to twenty-three per cent. *Neocosmospora vasinfecta*, two strains of *Rhizoctonia*, one definitely *R. solani*, and *Fusarium vasinfectum* were isolated by Dr. Mitra. The parasitism of *Fusarium vasinfectum* and the two strains of *Rhizoctonia* was established by infecting sterilized soil with pure cultures and growing disinfected seeds. In a plot heavily infested with last year's wilted sann-hemp plants this crop was grown and all the diseased plants were periodically removed and examined. Out of a total of 280 plants, 193 died of *Fusarium* and twenty-six of *Rhizoctonia*, giving 69·0 and 9·5 per cent. of wilt respectively. It was further observed that the deaths due to *Rhizoctonia* were mostly in the early stages of the growth of the plant and *Fusarium* wilt appeared a little later in the season.

Experiments carried out showed that the *rahar* strain of *Fusarium vasinfectum* can produce wilt in sann-hemp and *vice versa*, while the cotton strain of *Fusarium vasinfectum* does not infect *rahar* and sann-hemp, nor do the *rahar* and sann-hemp strains infect cotton. In an one-tenth acre plot heavily infested with *rahar Fusarium*, 204 plants of susceptible Dharwar cotton, 215 of susceptible *rahar* and 204 of sann-hemp were sown in alternate rows and at the time of harvest none of the cotton plants had died of wilt, while 72 per cent. *rahar* and 57 per cent. sann-hemp plants wilted. Eight plants of sann-hemp and 76 of *rahar* were grown in pots filled with soil infested with sann-hemp *Fusarium* and 92 per cent. of sann-hemp and 64 per cent. of *rahar* plants wilted. Among 78 plants of *rahar* and 60 plants of sann-hemp grown in soil infested with *rahar Fusarium* in pots the wilt percentage was ninety-two and fifty-three respectively. Forty plants of cotton were grown in pots infested with *rahar Fusarium* and forty in pots infested with sann-hemp *Fusarium* but none took infection.

(*vii*) Cicer arietinum

Mystrosporium sp.—The study of *Mystrosporium* sp. causing gram leaf blight in Pusa was continued. Experiments to control the disease were repeated and the effect of the following fungicides was tested :—Wet seed treatment—formalin and uspulun, dry seed treatment—sulphur and ceresan and spraying of plants with one

per cent. Bordeaux mixture and dusting with colloidal sulphur RV3. Seeds of types 68, 69, 70 and 71 were heavily infected and treated in some plots by wet or dry fungicides and in others sprayed or dusted when the plants came out. The disease did not appear in Types 70 and 71 even in infected plots but was bad in Types 68 and 69, especially in the former. One per cent. Bordeaux mixture sprayed once in three weeks was effective to a certain extent. The treatment will have to be repeated before any conclusion can be drawn.

During the year 60 types of gram were grown in the Botanical Area and four in the Farm on a field scale and in none of these was the disease noticed.

(*viii*) Phaseolus sp. and other Pulses

A study of species and strains of *Cercospora* on various pulses such as *Phaseolus radiatus*, *P. mungo*, *P. aconitifolius*, *Cyamopsis psoraliodes*, *Vigna catjang* and *Stizolobium* sp. was started by Udai Bhan Singh with a view to determine whether there are a number of species or merely strains of a single species. Single spore cultures were grown and the morphology studied. All the isolates are being compared under various standard conditions of growth in culture media. During the course of this study a large number of saltants appeared; these have been purified and are being compared with the parent forms. Inoculation and cross-inoculation experiments are in progress to determine the host range of each.

(*ix*) Cannabis sativa

A species of *Cercospora* was isolated from *Cannabis sativa*. The fungus forms dark brown elongated spots usually on the under-surface of the leaves and in severe cases a number of spots coalesce and destroy almost the whole leaf-area causing curling and drying of leaves. The morphology of the fungus was studied and it appears to be a new species.

(*x*) Jasminum angustifolium

A species of *Cercospora* was found to do considerable damage to the leaves of *Jasminum angustifolium*. The fungus attacks the under-surface and forms large dark brown spots. In advance stages the whole leaf is destroyed. The fungus appears to kill the leaf tissue in advance as no mycelium has been noticed in the discoloured area outside the central dead portion on which fructification is found. It appears to be an undescribed species. Another *Cercospora* was isolated from *Nyctanthis arber tristis* and is being compared with the above-mentioned species.

(*xi*) Panicum trypheron

A species of *Sclerospora* was recorded for the first time on this host and a study of its morphology shows that the fungus agrees with *Sclerospora sorghi* West. and Uppal. All attempts to induce the oospores to germinate have failed so far and consequently no infection took place when cross-inoculation was made on maize, jowar and other cereals.

(*xii*) Tobacco

Alternaria sp. A comparative study of the two forms of *Alternaria*, one causing stem-rot and the other forming leaf-spot of tobacco, is in progress and infection experiments are being conducted to test their pathogenicity and to determine whether the leaf-form can cause stem-rot and *vice versa*.

Stem-rot. The investigation on the stem-rot disease caused by *Sclerotinia sclerotiorum* (Lib.) de Bary was continued by K. F. Kheswalla. The optimum temperature for its growth was found to lie between 20-25°C. and the maximum at 30°C. beyond which the fungus ceases to grow. Microconidia develop profusely in water culture, agar and on potato agar, and on richer medium it is delayed till the food material is exhausted by the growing sclerotia. Further it was observed that microconidia develop from germinating ascospores on old apotheca. All attempts to induce microconidia to germinate failed so far. Low temperature was found to favour the development of apothecial stalks. Inoculated seedlings and seedlings grown in artificially infected soil took infection and formed sclerotial bodies in the central portion of the stem, thus establishing its parasitism.

(*xiii*) Cinchona

Inoculation experiments with *Verticillium* sp. and *Sporotrichum* sp. isolated from diseased cinchona plants were carried out by the Superintendent, Cinchona Plantation, Valparai, and gave successful results.

(*xiv*) Wheat

Tilletia indica Mitra. Bunt due to *T. indica* was noted by Dr. Mitra in a virulent form in Karnal on many of the wheat varieties grown at the Botanical Sub-station. Damage was up to 20 per cent. in some cases. Opportunity was taken to make more detailed observations, than have been possible so far. It was noted that in a spike only a few spikelets, about 1 to 5, are affected, complete infection of the spikes being absent. In unripe ears it is necessary to break the spikelets to see the diseased grain. In

advanced cases the glumes spread apart and the blackened inner wheat grain protrudes. Careful examination of the tip of the spikelet may sometimes show a black spot which is usually an indication of a diseased grain within. More often a lens is necessary to see the bunt. Because of the abundance of material, it was possible to find out that this bunt has also a distinct fishy smell like *T. tritici*. Germination of the spores has been secured but factors inducing profuse germination are not yet known. This bunt seems to be restricted to the cooler regions of the plains like Karnal and other Punjab districts, while the other two, *T. tritici* and *T. levis*, are restricted to the more cool hilly tracts. Extensive tests with seed treatments, both dry and wet treatment, have been planned for trial next year in order to check the disease, if possible.

H. tritici-repentis Died. on wheat, which forms leaf spots similar to *H. sativum*, was studied in culture. Of the several isolations two strains were common, one of which formed immature perethecia of the Pyrenophora type. The fungus does not sporulate in culture but on straw culture a very large number of sclerotial-like bodies appeared which later on formed immature perethecia and on their surface conidiophores appeared and formed conidia. Straw cultures at 20° C. and below formed more conidia but the perethecial bodies remained immature though in rare cases a few asci were noticed.

The percentage of leaf-area destroyed by *Helminthosporium sativum* P. K. and B. and *H. tritici-repentis* Died. was estimated on varieties of wheat grown at Pusa and Karnal respectively. With the exception of a few varieties in which the percentage of leaf area destroyed was up to 6·3, all the varieties and cultures at Karnal were free from the disease. A good deal of variation has been observed at Pusa in the percentage of attack not only from plot to plot but also in the same plot. In the samples examined the range of attack varied considerably, *e.g.*, P. 4 and P. 52 on the farm gave an average leaf destruction of 17·2 and 18·8 per cent. as compared to 6·7 and 2·3 in the Botanical Area.

Wheat rust. A survey of wheat rust on all the varieties of wheat grown in the Botanical Area and Farm at Pusa and on all the varieties grown in the Botanical Sub-station, Karnal, was made as in the previous year. At Pusa, the orange rust appeared as usual during X'mas and was first noticed on the 29th December, 1932. The yellow and black rust appeared rather late during the year and were first observed on the 3rd and 13th February 1933, respectively, as compared with the 16th January and 5th February of last year. As in the previous year, the attack by all the three rusts was mild except in the case of Bihar 121 which was rather heavily attacked with orange rust. Yellow rust was not so severe on P. 52 and P. 115 as last year.

The leaf surface covered by the rust postule was measured as in the previous year and the average percentage of leaf area affected in various varieties grown in Pusa is given below :—

Variety	Orange rust	Yellow rust	Variety	Orange rust	Yellow rust
P. 4 . .	0·04	..	P. 114	8·5	..
P. 6 . .	0·51	0·21	P. 115	..	0·95
P. 12 .	2·01	Traces	P. 80-5	0·37	..
P. 52 . .	0·03	0·18	Federation	..	..
P. 101 .	0·01	..	Bihar 121	17·3	2·0
P. 111 .	0·01	..	Muzaffarpur	8·0	5·4
P. 112 .	9·7	..	Muzaffarnagar	6·2	Traces
P. 113 .	8·3	..	8A	10·4	..
Country .	1·03	0·42			

At Karnal all the varieties were lightly attacked with orange rust. Yellow rust was fairly common on a number of varieties and the attack on P. 52 and P. 115 was as bad as last year. Black rust was absent except on certain Canadian and Japanese wheats of which the latter were badly attacked. At Pusa there is little yellow rust on P. 52 and P. 115, and it is suspected that the Karnal strain of yellow rust is physiologically different from that of Pusa and Dr. K. C. Mehta who is engaged on the study of wheat rusts has very kindly agreed to test this view by conducting a series of infection experiments.

At the request of Dr. K. C. Mehta aeroscopes were again placed in wheat fields and exposed slides were sent to him at regular intervals from the 15th September 1932 to the 15th March 1933. Similar slides were also exposed for the Section at various places including the roof of the Institute building and though a careful microscopic examination was made of these slides no wheat rust spores were observed until after the appearance of rust in the fields.

(*xv*) Barley

Dr. Mitra again made an estimate of the percentage of leaf-area destroyed by *Helminthosporium teres* and *H. sativum* on twenty-four types of barley grown in the Botanical Area. The intensity of the disease was found to be less than in the previous year. The percentage of leaf area destroyed by *H. teres* ranged

from 0·27 to 20·45 as compared with 0·5 to 25·4 of last year and that by *H. sativum* from 0·22 to 6·78 as compared with 1·2—14·2. An estimate of the percentage of leaf surface rendered ineffective by these two species of *Helminthosporium* was also made on twenty-six other Indian and foreign types of barley which are being tried at Pusa, and it was noticed that all the seventeen foreign types were free from *H. teres* and the attack by *H. sativum* was mild, the percentage of leaf destruction ranging from 0·1 to 1·85, on the other hand, all the nine Indian types, with the exception of one, were attacked by *H. teres*, the percentage ranging from 0·44 to 11·7, and all except three were free from the attack of *H. sativum*. Cawnpore 251 and Cawnpore 252 were the only types which were attacked by both the species.

The experiment to test the comparative resisting power of twenty-four types of Pusa barley varieties to *Helminthosporium* together with the effect of uspulun as a seed treatment was repeated, and six replications comprising 120 plots were laid down. All the seedlings which died of foot-rot or root-rot were removed twice a week and examined and when the crop was fully grown, the percentage of leaf area destroyed and the yields were estimated. All the figures obtained are being statistically examined. The efficiency of uspulun to control the *Helminthosporium* disease was again confirmed during the year, *e.g.*, T. 21 had an average attack of 0·05 per cent. in plots treated with uspulun, and with untreated seed the average was up to 4·72. That uspulun treatment also checks the attack by smut (*Ustilago hordei*) is illustrated by the following figures. In a plot sown with T. 21 and treated with uspulun, not a single smutted head was found among 6,650 plants, while out of 7,512 plants grown from the same seed but untreated the number of smutted plants was 114, giving 1·5 per cent. of smut.

Rust. Yellow rust, as in wheat, was severe at Karnal as compared with Pusa where the attack was mild on the same varieties of barley, only a few varieties escaped infection at Karnal, and here also a different physiological strain seems to play an active part.

(*xvi*) Chillies

The study of the wilt disease of chillies was continued and the pathogenicity of eight strains of *Fusarium* was tested in pots and in plots on four Pusa Types 34, 41, 46 and 51. Last year infection was found to take place in seedlings grown and infected in test tubes. Fresh isolations were made and the pathogenicity under all conditions was tested in pots, wooden boxes and plots, each plant being infected with a heavy dose of the fungus grown in stock culture, but no results were obtained. The effect of soil

moisture to produce wilt was also tested in sterilized pots in which soil moisture was regulated from 5, 10, 15 and 20 per cent. respectively and the soil was heavily infected but no plant died of wilt.

IV. MISCELLANEOUS

Sclerotium rolfsii. Comparative studies on various isolations from different hosts have been continued by Dr. Mundkur. While sclerotial size seems to be constant within a strain, it differs from other isolations in a steady and constant manner. Rates of growth on standard agar in Petri-dishes, with many replicates, differ statistically (using the Analysis of Variance tests) with different cultures. That there is physiological specialization is quite manifest but whether there is parasitic specialization remains to be seen. A Corticium stage appeared once in a culture, but it has not been seen since. Attempts are being made to obtain it.

Fruit tree diseases. A survey of diseases of fruit trees in British Baluchistan was undertaken during the year by K. F. Kheswalla and the following fungi were recorded there for the first time :— Apple—*Coniothecium chomatosporium* Corda. (blister disease), *Alternaria* sp. (apple rot), *Penicillium* sp. (soft-rot or blue mould), *Trichothecium* sp. (Pink rot), Jonathan spot (Physiological), leaf scorch (Physiological also on pear, walnut and apricot). Peach—(*Exoascus deformans* Fuckl. (leaf curl), *Cladosporium carpophilum* Thuem. (scab or freckles), Splitting of fruits (Physiological), *Phyllosticta* sp. (shot hole of peach, almond and apricot), *Gummosis* (all stone fruit trees). Grape—*Uncinula necator* (Schw.) Burr., Oidium stage (Powdery mildew), *Clasterosporium* sp. (leaf spot). Fig—*Capnodium* sp. (sooty mould). Pomegranate—*Sterigmatocystis castanea* Pott. (internal rot). Water-melon—*Phythium aphanidermatum* (Eds.) Fitz.

Coniothecium chomatosporium Corda. was recorded on apples received from Kulu and *Colletotrichum gloeosporiodes* Penz. on mango from Calcutta and also on citrus twigs from Cuttack.

Seedling diseases due to Rhizoctonia. Rhizoctonias isolated from various host plants are also under study but much progress has not however been made. In order to control the seedling diseases due to this fungus seed treatment was tried on chillies and tobacco. Mercury bichloride, uspulun, granosan, germisan were tested and in each case excellent results were recorded, the dust treatment (granosan) giving better result.

Sugarcane transpiration experiments. In order to determine the daily and weekly rate of transpiration of sugarcane expriments on a large scale have been started since last March and interesting data are accumulating. At the same time, in order to know the water content of soil in a typical unirrigated sugarcane field,

weekly determinations of moisture at 1″ to 6″ and 18″ to 24″ depths are being made, in such a manner that statistical examination of results would be possible.

Meteorological observations. As the cause, development and spread of many plant diseases are to a great extent controlled by soil and air temperatures, humidity and rainfall, meteorological observations are being carefully made, and data compiled. These data will help to find out why a disease is present or absent during a particular period of the year.

V. SYSTEMATIC WORK

Uromyces cicer-arietini (Grogn.) Jacz. Boy was recorded for the first time from Karnal, Punjab, on *Cicer arietinum* and *Rhizoctonia bataticola* (Taub) Butl. was noted on sugarcane at Pusa. A good deal of assistance was given to the Bihar and Orissa Department of Agriculture, in the investigation of the diseases of sugarcane, potato and other crops, including treatment of five hundred maunds of barley seeds against smut, and to the Bengal Department of Agriculture, in the investigation of the diseases of piper betel, rice and tobacco. A large number of diseased betel-vines were received from Bengal throughout the year for identification. Help was rendered to various workers in mycology and plant pathology in various Departments of Agriculture and Universities in the identification of diseases of cultivated and ornamental plants, supplying cultures and specimens of fungi and other information including methods of control. Specimens were received for identification from the public and the Indian States. Fresh specimens of wheat and barley rusts were supplied on several occasions to Dr. K. C. Mehta of Agra, for his investigation of cereal rusts. The Section usefully served foreign workers by supplying information, cultures and specimens, *e.g.*, to Dr. C. M. Tucker, Missouri (U. S. A.), cultures of five species of Phytophthora; to Dr. E. C. Tulis of Arkansas, culture of *Sclerotium oryzae*; to Dr. T. Matsumoto of Formosa, culture of *Hypochnus sassaki* Shirai; to Professor Johanna Westerdijk of Holland. *Fusarium moniliforme* and eleven other sugarcane fungi: cultures of *Sclerotium rolfsii* and *S. oryzae* to Professor Curzi of Rome. Thirty-six specimens of *Cercospora* were received from the Director, Bureau of Science, Manila, P. I., in exchange for an equal number of Indian *Cercosporas*. Eleven specimens from the Professor of Botany, Khalsa College, Amritsar, 160 specimens of miscellaneous fungi from Dr. J. H. Stevenson of Washington and 150 specimens from Dr. H. Sydow of Berlin, were received in exchange.

Acknowledgment is due to Dr. J. J. Taubenhaus, Texas (U. S. A.), for identifying cotton root-rot specimens, to Dr. K. Nakata, of Imperial University, Fukuoka, Japan, for supplying cultures of

Sclerotium oryzae sativa and *S. sphaeroides*, to Dr. T. Matsumto, Formosa, for comparing the Indian strain of *Hypochnus sassaki* on sugarcane, and to Professor Johanna Westerdijk of Holland, for confirming our identification of *Fusarium moniliforme*.

VI. PROGRAMME OF WORK FOR 1933-34

1. Research work

New diseases of Indian crops that come to the notice of the Section will be investigated. Diseases on the following crops will receive special attention :—Sugarcane, wheat, barley, rice, Piper betel, gram, sann-hemp, tobacco, *Hibiscus sabdariffa*, potato and pulses.

The investigations in progress include :—

(*i*) Experiments to determine the resistance of Co. varieties of sugarcane to mosaic and tonnage experiments to determine the loss due to mosaic.

(*ii*) Experiments to find out suitable remedial measures to check the diseases of Piper betel.

(*iii*) A study of the diseases of cereals and sugarcane caused by species of *Helminthosporium* and determination of percentage of rust and *Helminthosporium* on various varieties of wheat and barley.

(*iv*) Studies on various sclerotial and other diseases of rice including the wilt disease caused by a species of *Cephalosporium*.

(*v*) Stem-rot disease of *Hibiscus sabdariffa* and tobacco caused by *Sclerotinia sclerotiorum*.

(*vi*) A comparative study of various strains of *Sclerotium rolfsii* and *Rhizoctonia solani*.

(*vii*) Wilt disease of sann-hemp caused by *Fusarium vasinfectum*.

(*viii*) A study of the bunt disease of wheat caused by *Tilletia indica* and remedial measures.

(*ix*) A comparative study of *Cercospora* on pulses and other crops.

(*x*) Sugarcane transpiration experiments and meteorological observations.

(*xi*) Fruit tree diseases.

2. Training

Students and assistants will receive training on the lines indicated in the prospectus.

3. Routine work

Advice and assistance as required will be given to other departments and the general public.

VII. PUBLICATIONS

McRae, W., and Subramaniam L. S.	Effect of Mosaic on the Tonnage and Juice of Sugarcane in Pusa, Part III, *Ind. Jour. Agri. Sci.*, Vol. III, October 1933, pages 870—880.
Singh, U. B.	Physiology of *Cercospora dolichi* E. & E. *Ind. Jour. Agri. Sci.*, Vol. III, June 1933, pages 496—529.
McRae, W., & Shaw, F. J. F. .	Influence of Manures on Wilt Disease of *Cajanus indicus*. Scientific Monograph No. 7 of the Impl. Council of Agric. Research.

(2) SCHEME FOR RESEARCH ON MOSAIC AND OTHER DISEASES OF SUGARCANE

(Financed by the Imperial Council of Agricultural Research)

I. INTRODUCTION

Though work on the diseases of sugarcane has formed a substantial amount of the activities of the Mycological Section at Pusa, it was limited by the size of the staff available after giving due consideration to the claims of other crops. A five-year scheme providing for the appointment of a Class I officer, a Class II officer, and a Research Assistant and a Fieldman in the subordinate service whose whole time may be devoted to research on mosaic and other diseases of sugarcane was therefore submitted to be financed by the Imperial Council of Agricultural Research as soon as the Council was constituted. The scheme was accepted by the Council in 1930, but, owing to financial stringency which supervened, final orders sanctioning a non-recurring grant of Rs. 12,000 and a recurring grant of Rs. 53,000 to be spread over a period of three years, were not received until the second week of May 1932. The scheme was accordingly started with effect from the 1st June 1932, and Dr. S. V. Desai, Second Assistant Agricultural Bacteriologist of this Institute, was appointed Sugarcane Mycologist, with effect from the 27th June 1932. Mr. S. A. Rafay was appointed Research Assistant from the 17th October 1932, but the post of Assistant Sugarcane Mycologist was not filled until the 23rd June 1933, when Mr. L. S. Subramaniam, an Assistant in the Mycological Section, was appointed.

An intensive study of the mosaic virus has been taken up, and a new line of attack has been developed to find out the nature of the mosaic diseases. The effect of the mosaic disease on the tonnage of sugarcane has been initiated at the Patna and Cawnpore farms and with the equipment and the land available at Pusa substantial addition to the knowledge regarding the mosaic and other diseases of sugarcane is anticipated.

II. MOSAIC DISEASE OF SUGARCANE

Distribution

In addition to the localities and varieties reported to be affected with mosaic in previous reports of the Mycological Section, the

following canes have been observed to have mosaic disease in the localities noted :—

Bihar—Patna (Farm)—Co. 285, 300, 313, 331, Amritsar Ponda and Sialkot Ponda. Mushari (Sugarcane Research Station)*—Hemja, Chynia, Yuba, Maneria, Mungo, Lewari, Ketari, Barnkha, Co. 317 to 320, 325, 326, 330, 332 to 335, 339, 342, 343, 346, 349, 352, 353, 357.

Bengal—Dacca (Farma)—Co. 281 and 320. Mymensingh (Farm)—Co. 213.

Punjab—Gurdaspur, Jallundur and Lyallpur (Farms)†—Co. 203, 213, 281, 300, 301, 312, 318, 343, 344, 346, 347, 349, 350, P. O. J. 2878, Saretha, Katha and Naba.

C. P.‡—Co. 210 and Red Mauritius.

Madras‖—Central Farm, Coimbatore—Co. 360, 361, 408, H. M. 320, 332, and 544. Nellikupum—Co. 205.

Bombay—(Padegaon Farm)—H. M. 213 (Java Hebbal).

The Imperial Cattle-breeding Farm at Karnal was free from mosaic disease, but in June 1933 two local varieties in the block allotted to the Sugarcane Sub-station were found to be affected with mosaic, *viz.*, Dhaulu of Batala and Katha, the percentage of attack being 8 and 63 respectively.

Artificial transmission of mosaic

Season plays an important part in producing the disease by artificial inoculation, the period before the setting in of rains (from April to June) being the most suitable for successful artificial transmission. It is curious that sunshine facilitates the artificial transmission of the disease.

A series of experiments were carried out to find out the optimum conditions for successful artificial inoculation of the mosaic disease. The following four methods of inoculation were tried to find out their efficiency in producing the disease under three atmospheric conditions, *viz.*, humid, shade and sunshine :—

Method A.—Hypodermic needle injection (finest possible needle).

Method B.—Insertion of fragments of mosaic infected tissue into healthy plants.

*Reported by Sugarcane Specialist, Bihar.

†Reported by Associate Professor of Botany, Lyallpur.

‡Reported by Government Mycologist, C. P.

‖Reported by Government Mycologist, Madras.

Method C.—Wrapping tightly a sugarcane leaf showing mosaic infection round the spindle of a cane stalk to be inoculated and rapidly pricking with fine pin (insect) through the mosaic leaf and spindle, 15 times.

Method D.—Gentle rubbing over a large leaf surface with a cloth soaked in juice from mosaic plants.

1. Humid condition was created by placing the pots in a shady place which was surrounded by water.

2. Shade condition was maintained by keeping the inoculated pots in such a position that sunlight did not fall directly on the plants throughout the day.

3. Sunlight condition was maintained by putting the inoculated pots in such a position in the open that sunlight fell direct on the plants throughout the day.

Out of these methods, C was found to be the most efficient one for producing the disease in a series of experiments. When this method was used the period of incubation was the shortest and cent. per cent. infection of plants occurred under favourable natural conditions.

Sunlight condition has been found to be favourable in visible transmission of mosaic in a short time in the inoculated plants in contrast with the humid and shade conditions as tabulated below :—

No. of shoots showing mosaic in different weeks.

Experimental condition	Date of inoculation	Method	No. of shoots inoculated	15th to 21st April	22nd to 28th April	29th April to 5th May	6th to 12th May	13th to 19th May	20th to 26th May	27th May to 2nd June	3rd to 9th June	Total No. of infections	Incubation period	
													Maximum weeks	Minimum weeks
I. Humid .	15-4-1933	(a)	20	..	..	..	1	2	2	1	..	6	7	4
		(b)	21	..	..	..	2	5	3	..	..	10	6	4
		(c)	18	..	..	12	5	1	..	..	..	18	5	3
		(d)	21	..	..	1	4	5	3	2	..	15	7	3
II. Shade .		(a)	32	..	..	1	3	2	1	..	..	7	6	3
		(b)	20	..	..	..	..	5	1	..	..	6	6	5
		(c)	19	..	..	7	4	..	..	..	..	11	4	3
		(d)	25	..	..	1	..	1	2	..	..	4	6	3
III. Sunshine .		(a)	20	..	7	6	..	1	2	..	..	16	6	2
		(b)	21	..	..	..	3	4	2	..	..	9	6	4
		(c)	22	..	17	4	..	1	..	..	..	22	5	2
		(d)	17	..	..	4	1	1	..	..	..	6	5	3
					SERIES II.									
				10th to 16th May	17th to 23rd May	24th to 30th May	31st May to 6th June							
I. Humid .	3-5-1933	(a)	10	2	..	..	5					7	5	2
		(c)	10	2	6	..	2					10	5	2
III. Sunshine .		(a)	10	1	1	..	3					5	5	2
		(d)	10	4	5	..	..					9*	3	2
		(c)	10	..	3	..	2					5	5	3

*1 killed by white ants.

Cultivation of mosaic virus in vitro.

Experiments were devised to induce the multiplication of the virus *in vitro*, but so far no conclusive evidence has been adduced. Tissue culture and other methods have failed to give a culture which reproduces the disease. This should not be taken as an evidence of non-multiplication in vitro because the sugarcane mosaic virus is very susceptible to ageing and Chamberland candle filtrates have invariably failed in reproducing the disease. The virulence of the virus is destroyed by so many factors that it is advisable to keep the question open.

While carrying on cultivation experiments it was found that the transfers of the mosaic virus in series in alkaline broth induce a capricious pleomorphic growth. The juice of healthy tissues failed to give similar phenomenon. As this phenomenon was observed in repeated series of duplicated experiments, the detailed procedure is given below :—Juice of mosaic infected as well as healthy leaves was obtained by crushing them in a mortar with a small amount of water. The juice was successively filtered through a cloth, a filter paper and a sterile Chamberland filter candle L3 or L5 ; 0·5 c. c. of the filtrate was inoculated into 10 c. c. of sterile broth having a reaction of pH 7·8. The broth best suited for the purpose had the following composition :—

Peptone	5 grm.	Broth was adjusted to pH7·8 and was sterilized at 120°C. for 20 minutes.
Marmite	3 grm.	
Lithium chloride	2·5 grm.	
K_2HPO_4	0·2 grm.	
$MgSO_4$	0·2 grm.	
Sucrose	2·0 grm.	
H_2O	1,000 c.c.	

The inoculated broth tubes were incubated at 30°—37°C. for three to five days.

No visible growth developed during the incubation of first transfers. The broth was then filtered through sterile Chamberland filter candle and 0·5 c.c. of this filtrate was inoculated into a series of fresh broth tubes, generally in duplicate and triplicate and incubated. After five days' incubation, transfers from these cultures were made into fresh tubes after filtration. One set was set aside for prolonged incubation to see if any growth developed thereby. In this way a series of transfers were carried out both with mosaic and healthy juice. It was observed that after 10 transfers a slight haziness developed in transfers started from the juice of mosaic infected leaves. The broth was spread on nutrient agar and various other stock agar media but no growth could be discerned on the surface. The haziness increased in the next transfer and spreading of the broth on nutrient agar gave very minute colonies on the agar surface. Most of these colonies failed to give growth on transfer and some gave discontinuous growth

with innumerable minute separate colonies. Further cultivations in broth as well as on agar ultimately gave a heavy continuous growth with small clear depressed areas, similar to bacteriophagic plaques.

The biochemical reactions of the organisms were studied. The growth of the organisms in these culture media was meagre, and the characteristics varied unaccountably. Repeated planting and other culture methods failed to separate the culture into organisms with well established different characteristics. The organisms obtained differed in biochemical reactions from those obtained from tomato mosaic but the growth characteristics and other cultural behaviour were found to be similar.

Attempts to produce the mosaic disease by inoculating the cultures and filtrate of the organisms have so far been unsuccessful. Mosaic-free stock of very susceptible varieties is being multiplied as material for inoculation with these cultures. As long as the conditions which adversely affect the virulence of the sugarcane mosaic virus are not understood, the artificial inoculations with material kept *in vitro* are likely to be unsuccessful.

Effect of mosaic virus on algae

The effects of mosaic virus on unicellular chlorophyll bearing organisms were studied. It was observed that the juice of the mosaic-infected leaves filtered through sterile Chamberland filter candle stimulated the growth of a widely distributed unicellular Coccoid algæ of the Pleurococcus Order belonging to the genus *Chlorella*. The juice of healthy leaves under similar conditions had no effect on the growth. Only 0·2 c. c. of the filtered juice was added to 10 c. c. of Kleb's solution in which the alga was inoculated. These effects were confirmed in several series of experiments.

Effect of mosaic on chlorophyll contents

The estimation of chlorophyll in the mosaic infected and healthy leaves has been taken up. Badly affected mosaic leaves of Co. 213 contained 20 per cent. less chlorophyll than the healthy ones. The comparative distribution of chlorophyll leaf by leaf in Co. 213 is given below :—

1st	youngest	open	leaf	47%	of	similar	leaf	of	healthy	plant.	
2nd	,,	,,	,,	75%	,,	,,	,,	,,	,,	,,	
2nd	,,	,,	,,	84%	,,	,,	,,	,,	,,	,,	
4th	,,	,,	,,	95%	,,	,,	,,	,,	,,	,,	

Tonnage experiments in co-operation with Provincial Departments of Agriculture

In order to study the effect of mosaic on the yield and juice of sugarcane under different climatic conditions and under irrigation, two experiments have been started at Patna and Cawnpore Farms in collaboration with the Deputy Director of Agriculture, Patna, and the Plant Pathologist, U. P.

In Patna Farm mosaic-free plots of the tonnage experiment and the adjoining non-experimental plots were found to be affected with smut, the infection varying from 1·2 to 2·1 per cent. Control measures were carried out.

III. RED STRIPE DISEASE OF SUGARCANE

The occurrence of the red stripe disease of sugarcane has been established for the first time in India. Red stripe disease is characterized by two definite types of lesions, (1) that caused by infection of the leaves and (2) that caused by infection of the growing point. Long needle-like red stripes may be formed in any portion of the leaf blade but generally they appear at or near the base of the leaf blade. They are bright red and follow the course of the vessels. They often coalesce and form a broad lesion. As the leaf matures these lesions assume chocolate-brown colour. Lesions on the growing point bring about top-rot conditions. On splitting open fine needle-like red lines could be traced in the unfurled leaves reaching the growing point. The disease is caused by bacterial infection. The causative organism has been isolated. The biochemical reactions differ slightly from those of *Phytomonas rubrilineans* and *Phytomonas rubrisubalbicans*, which are known to cause the red stripe in other sugarcane-growing countries. The organism is usually associated with a species of *Fusarium* in the diseased tissues but inoculations with *Fusarium* alone failed to reproduce the typical red stripe condition. The organism alone is able to induce the red stripe and top-rot but rather slowly. The *Fusarium* alone also produces a kind of top-rot and local lesions are usually produced. These lesions are blotchy and quite distinct in appearance from typical red stripe lesions. Artificial production of red stripe and top-rot condition is induced very quickly by inoculation of the organism and *Fusarium* together.

The disease occurs in young canes before the break of the monsoon, and decreases with the progress of the monsoon. It was observed to occur on the following varieties in different localities :—

Pusa—Co. 210, 213, 214, 299, 303, 304, 312, 313, 315, 316, 321, 322, 331, 333 to 337, 339, 343, 344, 348, 382, 385, 386, 387 397, Uba and Chunne.

Sepaya—Red stripe—Co. 210, 213, 297 to 301, 303, 312, 313, 318, 320, 321, 322, 326, 329, 331 to 339, 341, 342, 343, 345 to 350, 353. 354, 356, B. S. 7. 10 and P. O. J. 2696.—Red stripe mixed with top rot—Co. 210, 213, 281, 285, 297 to 301, 303, 312, 313, 317, 318, 319, 321, 322, 323 and 325 to 353.

Dacca—Co. 204, 213, 223, 300, 343, 347, 349, 351, 360, 361, 364, 368, 370, 372, 373, 377, 378, 379, 382, 384, 391, 404, 407, 410 to 413, H. M. 544 striped, P. O. J. 2714, 2725, 2727, 2878 and Badila.

At Dacca and Sepaya the disease has assumed serious proportions, the incidence being as much as 80 per cent. in some varieties. The disease does not kill the cane outright but the growth is checked and in cases where the top shoot is affected it causes appreciable loss.

IV. SYSTEMATIC WORK

During the year under report, 17 bundles of specimens of diseased sugarcane were received from various Government farms for examination and report. Cultures of red stripe disease organisms were received from the Fibre Expert to the Government of Bengal, Dacca, for comparison with Pusa strains. It was found that one of his strains was similar to the organisms causing the red stripe disease at Pusa and Sepaya. The virulence of the organisms was lost by long cultivation on agar.

V. PROGRAMME OF WORK FOR 1933-34

I. Mosaic disease—

(1) Survey of the mosaic disease in India.

(2) Artificial transmission of sugarcane mosaic to hosts other than sugarcane.

(3) Cultivation of mosaic virus in vitro, identification of the culture obtained from mosaic tissues. Study of the serological reactions of mosaic virus and the organisms obtained from diseased tissues.

(4) The study of the physiological and histological changes brought about by mosaic disease in sugarcane.

(5) Effect of various physical and chemical factors on the virulence of the sugarcane mosaic.

(6) Tonnage experiments to see the effect of mosaic on the yield and juice of canes.

(7) Varietal test experiments to see the natural spread and resistance of different varieties.

II. The study of the red stripe disease and its control measures.

III. Sugarcane fungus diseases—

(1) Comparative study of different isolates of *Colletotrichum falcatum* from thick and thin canes, to see if there are physiological strains.

(2) Study of *Fusarium moniliforme* causing top rot and control measures.

(3) Isolation of various fungi from different localities and various varieties in order to see whether Indian strains are identical with those in other countries.

REPORT OF THE IMPERIAL ENTOMOLOGIST

(P. V. ISAAC, B.A., D.I.C., M.Sc.)

I. ADMINISTRATION

I held charge of the Section throughout the year in addition to my own duties as Second Entomologist (Dipterist).

Rai Bahadur C. S. Misra, Assistant Entomologist, was on leave from the 13th May 1933 to the end of June 1933.

One new Class II post was sanctioned but has not been filled yet.

II. TRAINING

One post-graduate student from the North-West Frontier Province was admitted for training.

The Professor of Zoology, Agricultural Institute, Allahabad, United Provinces, was under a special course of training in entomology from the 17th October 1932 to the 12th April 1933.

Two post-graduate students from the Aligarh University worked in the laboratory during the months of April and May 1933.

III. INSECT PESTS

Sugarcane

In Pusa, *Aleurolobus barodensis* Mask. and *Neocerataskellia bergii* Sign. appeared in August and reached their maximum activity in the middle of December. *Gryllotalpa africana* Pall. and some Elaterid grubs injured cane seedlings. Larvae of *Myllocerus discolor* Boh. were present in large numbers on roots of cane.

During July to November large numbers of *Pyrilla* spp. were present on sugarcane after which they became fewer. In July, 222 egg-masses were collected from a plot measuring 33·79 acres and the number of egg-masses collected increased in August and subsequent months. The parasitization of the eggs varied from 84·9 per cent. in September to 95 per cent. by the end of October.

In cane planted in February 1932, *Scirpophaga nivella* Fb. heavily oviposited on seedlings in the early months of the year. In July, 878 egg-masses were obtained from an area measuring 58·60 acres and 247 egg-masses from an acreage of 31·08.

As a result of systematic collection of the egg-masses throughout the active period of the vegetative growth of cane the attacks of this top-shoot borer were comparatively less in the cane plots under observation.

Help was given to the Mycological Section throughout the season in keeping the insect pests in check in the mosaic experimental plots. The egg-masses of the top-shoot borer *Scirpophaga nivella* Fb. were collected and destroyed and "dead hearts" and damaged shoots were removed. The plots were treated occasionally with 0·5 per cent. crude oil emulsion against termites. The burrows of rats damaging canes were located and fumigated with calcium cyanide dust.

At the time of harvest during the end of January 1933, the percentage of damage by *Scirpophaga nivella* Fb., stem-borers, *Emmalocera depressella* Swinh., and termites in the tonnage experimental plot was found to be as given in the Report of the Imperial Mycologist (page 136).

From samples taken at random, from the Imperial Agriculturist's plots in the New Area, Pusa, the average loss in weight in mosaic-free Co. 213, caused by the top-shoot borer *Scirpophaga nivella* was found to be 15·4 per cent.

Other Pests

Diacrisia obliqua Wlk. infested *meth* (*Phaseolus aconitifolius*), *til* (*Sesamum inflicum*), peas, castor, *masuri* (*Lens esculenta*), linseed, cabbage and cauliflower. It was specially bad in *meth* and linseed. *Pieris brassicae* Linn. did considerable damage to cabbage. *Athalia proxima* Klug. was abundant on turnips and mustard and was controlled by dusting with calcium cyanide. *Utetheisa pulchella* Linn. was bad on sann-hemp (*Crotalaria juncea*). *Zonabris phalerata* Pall. considerably damaged flowers of vegetables belonging to Fam. Cucurbitaceae. *Agrotis ypsilon* Rott. was checked by poison baits. *Eugnamptus marginatus* Pasc. attacked fresh leaves of mangoes in July and August. *Earias fabia* Stoll. was present in large numbers on *Hibiscus esculentus* and *H. abelmoschus*. There was a heavy attack of *Sylepta derogata* Fb. on cotton. *Bemisia gossypiperda* Misra and Lamba was also present, though in small numbers, on cotton.

The linseed crop of the Botanical Section was attacked by a Cecidomyid fly the pinkish larvae of which were found feeding upon the pollen of the flowers in March 1933. Light trap against adult flies was set up for about two weeks and a fairly good number of flies were killed.

Samples of stored *gur* (raw sugar) from sugarcane and palmyra palms, received from the Assistant Director of Agriculture, Gaya, were found infested by Nitidulid beetles, *Carpophilus obsoletus* Er. and *C. hemipterus* L., and their grubs. To prevent infestation by the beetles and their grubs it was suggested that *gur* should be wrapped in gunny and kept under *bhusa* (bran) or in containers the mouths of which should be securely closed.

Poison baits consisting of sweetened bran mixed with barium carbonate or potassium cyanide and made into a paste, and fumigation with cyanogas were tried against rats reported to be causing damage in paddy fields and stored rice in a godown at Sabour. The bait containing barium carbonate was more successful than the one containing potassium cyanide.

A preliminary survey of the various insect pests that were reported to be causing enormous damage to the fruit trees in the Fruit Experimental Station, Quetta, and other fruit growing areas in Baluchistan was made. The San José scale *Aspidiotus perniciosus* Comstock, the black scale *Lachnus persicae* Choldok, the green scale *Myzus persicae* Sulz. and the beetle *Scolytus rugulosus* Ratz. were found doing considerable damage to trees of almond, apple, pear, peach, plum and quince. The grubs of a Cerambycid beetle were found boring through the stems and branches of peach, apple, almond, cherry and quince.

In the Insectary the life-histories of about eighty insects were studied partly or fully and some of these have been illustrated mainly in black and white to record the results obtained. The local flora was examined throughout the year with a view to find out the presence of insects or their immature stages at different seasons. Young larvae of *Acherontia styx* Westw. were found feeding on leaves of *Jasminum sambac*. Young caterpillars of *Polytela gloriosae* Fb. collected on leaves of *Crinum* sp. on 25th October 1932 became full-grown on 2nd November 1932. A larva pupated on the 10th November 1932. Hibernation in the pupal stage lasted for about seven months, the moth emerging on 4th June 1933.

Some observations on the habits and habitats and the life-histories of the Asilidae of Pusa have been made.

IV. BEES AND LAC

Apiculture

Advice regarding bee-keeping was given to eighty enquirers. There was a greater demand than during last year for bee hives, queen excluders and the artificial comb foundations for *Apis indica*. These were supplied to correspondents from different parts of India. The use of different appliances employed in bee-keeping was also demonstrated to several visitors.

Lac

The emergence of lac larvae at Pusa took place on 17th October 1932 and on 23rd June 1933. The temperature during the months of May and June 1933 was much lower than what it was last year, and no damage happened to the lac crop by excessive heat.

V. INSECT SURVEY

Collections were sent out for identification to the following specialists and their help is gratefully acknowledged :—

Termites to the Director, Imperial Institute of Entomology, London.

Jassidae to Dr. H. S. Pruthi, Zoological Survey of India, Calcutta.

Chalcididae, Ichneumonidae and Thrips to Dr. T. V. Ramakrishna Ayyar, Coimbatore, Madras.

Earis sp. to Miss A. E. Prout, England.

Aphididae to Mr. R. Takahashi, Japan.

The following collections were received back identified :—

Thrips and Aphids from Dr. T. V. Ramakrishna Ayyar, Government Entomologist, Madras.

Hymenoptera from A. Wetmore, U. S. National Museum, Washington.

Gryllidae from The Imperial Institute of Entomology, London.

Simuliidae from Dr. I. M. Puri, Malaria Survey of India, Kasauli.

Indian insects were supplied to certain correspondents as listed below :—

Some named Diptera of economic importance to the Assistant Entomologist, Lyallpur, Punjab.

Cecidomyidae to Dr. H. S. Pruthi, Zoological Survey of India, Calcutta.

Muscidae to Prof. W. S. Patton, Liverpool.

Specimens of *Paederus fuscipes* Curt. to the Entomologist to Government, Punjab, Lyallpur.

Some specimens of *Sphaerodema* to Dr. C. J. George, Bombay.

Four show cases of insect specimens of economic interest to the Imperial Economic Botanist for the Botanical Substation at Karnal.

Some named specimens of Indian Trypaneidae to Mr. F. A. Perkins, University of Queensland, Australia.

Insect specimens were received for identification from forty-five correspondents in India and they were named as far as possible.

VI. PROGRAMME OF WORK FOR 1933-34

Major

This will follow generally on the lines of work of the current year and will include investigations of crop pests especially those damaging sugarcane and fruit trees, stored grains pests and blood-sucking flies of cattle.

Minor

Life-histories of insects will be worked out as opportunities offer. New insecticides and control methods will be tested as occasion arises. Systematic work will be carried on with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all enquirers on entomological subjects.

VII. PUBLICATIONS

The following publications prepared by the staff have been issued during the year :—

Bhatia, H. L., and Shaffi, M. . Life-histories of some Indian Syrphidae. (*Ind. Jour. Agri. Sc. II*, 543-570, Pls. 1-8, December 1932.)

Fletcher, T. Bainbrigge . . Life-histories of Indian Microlepidoptera, Second Series: Alucitidae, (Pterophoridae), Tortricina and Gelechiadae. (*Sc. Mono. 2 of Imp. Coun. Agri. Res.* July 1932.)

Isaac, P. V. . . . . Papers on Indian Tabanidae, IX—The Life-history of *Haematopota roralis* Fab. (*Ind. Jour. Vet. Sc. and Animal Husb.*, II, 278-280, Pl. 1, September 1932.) Notes on *Paederus fuscipes* Curt., A beetle which causes vesicular dermatitis in Man. (*Agri. and Live-stock in India*, II, 33-36, Pl. 1, January 1933.)

Misra, C. S. . . . . The Green Peach-Aphis (*Myzus persicae* Sulz.) and a new Pyralid Mango defoliator (*Orthaga mangiferae*, n. sp.) (*Ind. Jour. Agri. Sc.* II, 536-541, Pls. 1-3, October 1932.)

Mathur, R. N. . . . Notes on the Bionomics of *Odontomyia cyanea* Brunetti (Dipetra : Stratiomyidae) (*Ind. Jour. Agri. Sc.* III, 369-376, Pls. 2, April 1933.)

The following papers were submitted for publication :—

"The life-history of a common house cockroach, *Periplaneta americana* Linn.," by Mr. L. N. Nigam.

"Biological Control of insect pests and the possibility of utilisation of *Trichogramma minutum* Riley in India for the control of sugarcane borers," by Mr. E. S. Narayanan.

"The chief insect pests of Sugarcane and methods for their Control," by P. V. Isaac and Rai Bahadur C. S. Misra.

"The complete life-history of *Tabanus speciosus* Ric., a blood-sucking fly of cattle," by P. V. Isaac.

"The life-history of *Paederus fuscipes* Curt., a Staphylinid beetle causing 'Spider lick'—a vesicular dermatitis' in man," by P. V. Isaac.

"Lists of Publications on Indian Entomology for the years 1930, 1931 and 1932," compiled by T. B. Fletcher and P. V. Isaac.

REPORT OF THE BACTERIOLOGICAL SECTION

(N. V. JOSHI, B.A., M.Sc., L.Ag.)

I. ADMINISTRATION

Mr. Joshi, Assistant Agricultural Bacteriologist, held charge of the Section throughout the year.

Dr. S. V. Desai was appointed, with effect from 1st June 1932, to the newly-created post of Second Assistant Agricultural Bacteriologist and was closely afterwards appointed to the post of Sugarcane Mycologist.

II. TRAINING

No post-graduate students were admitted during the year.

A Demonstrator in Plant Physiology from the Hindu University, Benares, a post-graduate student of the Imperial Institute of Animal Husbandry and Dairying, and a research student from Bombay worked in the laboratory for short periods and were helped with their investigations.

III. SOIL BACTERIOLOGY

The two series of rotation experiments started three years ago to test the influence of leguminous crops on the conservation of soil nitrogen were continued. As in previous years, the figures for total nitrogen remaining in the soil at the end of two years were less than at the beginning of the experiment in the winter series, but in the *kharif* series they were higher. Taking into consideration the nitrogen removed by the crops, a gain in nitrogen is found in all the plots of both the series. The highest gain calculated in this way is 363 lb. per acre in the *kharif* (summer) series with the mixed crop of maize and *urid* (*P. radiatus*) and 360 lb. in the *rabi* (winter) series with maize and field pea (*Pisum arvense*) grown in rotation.

For a number of years observations on the toal nitrogen content of the soil in experimental plots in the pot culture area, as well as in *dhab* (low-lying) area, have shown that there is a seasonal fluctuation in nitrogen of the soil. This natural fluctuation in nitrogen is of importance in the nitrogen fixation observed in field soils, because if the sample of soil be taken in the low nitrogen season, it may show a rapid gain in nitrogen after incubation in the laboratory ; while the soil taken in the high nitrogen season

may show a loss in nitrogen when incubated in the laboratory. Therefore unless these natural fluctuations in nitrogen are carefully observed for any soil, it is not possible to get a correct idea of the average nitrogen fixation in the soil.

In order to correlate the observations on the fluctuation of total nitrogen of the soil with the nitrogen fixation taking place in the soil, attempts have been made to find out the nitrogen-fixing organisms that are active in the soil at different periods. For this purpose, in addition to the growth of organisms after inoculation of the soil in nutritive media, direct observations of the organisms active in the soil have been made by inserting clean sterile glass slides in the soil in the field, as well as, in the same soil kept in a beaker and incubated at laboratory temperature; and it has been found that in April, May and June the *Clostridium* species are the predominant type, especially after the rains or when moisture is added to the soil. The organisms of the azotobacter type are present but do not appear to multiply as rapidly as the *Clostridium* species. Incidentally it has been observed that, below the depth of one-fourth to three-fourth inch, hardly any azotobacter cells are present, the organisms found being exclusively of the *Clostridium* species. It appears, therefore, that the importance of the *Clostridium* group of organisms in adding nitrogen to the soil is much greater than that of the azotobacter group, whose claims perhaps are somewhat exaggerated by previous workers on account of its capacity for fixing large amounts of nitrogen in pure culture.

During the course of investigation on the nitrogen content of the soil in the experimental plots, it was observed that in some years at the time of harvesting maize the nitrogen content of the soil was higher than that at the time of sowing. Experiments were, therefore, carried out to see whether the maize root secretes any substance which can stimulate nitrogen fixation in the soil. For this purpose maize plants grown in the field were uprooted after a week's growth and, after washing their roots, were immersed in distilled water contained in a beaker for twenty-four hours after which time the plants were taken out. It was expected that water in the beaker would extract the substance or substances which the maize plant is likely to secrete in the soil to stimulate nitrogen-fixing organisms. It was proposed to see the effect of the addition of the water extract obtained as above and termed "maize root washings" on the nitrogen-fixing organisms. For this purpose the maize root washings after different treatments aiming at the removal of the bacteria associated with maize roots were added to a mixed culture of nitrogen-fixing organisms growing in Ashby's mannite solution, inoculated with soil and it was found that the root washings after passing through Pasteur filter candle as well as after being heated to 100°C. for 30 minutes stimulated nitrogen fixation. It appears, therefore, that in certain years if the season

is favourable maize plants may secrete a greater amount of root secretions in the soil, and there may be a greater accumulation of nitrogen in some seasons as an effect of the stimulation of the nitrogen-fixing organisms by the maize root secretions.

Green Manures

The field experiment started last year to compare the manurial value of sann-hemp with *urid*, and sann-hemp tops applied later in the season so as to secure the stems for getting fibre out of them, was continued, but the treatment of plots was reversed so that an original difference in the fertility of the soil may not influence the results of any particular treatment.

The net profit reported after meeting the cost of production for the years 1931-32 and 1932-33 are as under :—

Treatment	1931-32 Net profit per acre	1932-33 Net profit per acre
	Rs. a. p.	Rs. a. p.
1. Wheat after maize . . .	3 12 0	22 14 9
2. Wheat manured with *urid* . .	16 2 0	14 11 2
3. Wheat manured with sann-hemp .	20 8 0	12 2 2
4. Wheat manured with sann-hemp tops and fibre extracted from the stems	41 1 8	9 4 4

It appears that there is some inequality in the fertility of the experimental area as the same plots under treatment " wheat after maize " in 1931-32 were under the fourth treatment in 1932-33 and in both years they have given the lowest economic returns, and hence only after running the experiment continuously for some years can the superiority of any of the treatments be established. The seasonal effect on crops also played a great part in the experiment in 1932-33 and contributed to the large amount of net profit for the maize-wheat rotation. The yield of fibre from sann-hemp has continued to be about 8 maunds per acre but its value has gone down by 25 per cent. in 1932-33. This reduction in price contributed to lower the net profits from treatment No. 4 wheat manured with sann-hemp and fibre extracted from it last year.

A similar experiment on plots of 1/5 acre and Latin Square lay-out with five treatments and five replications was carried out on the farm and the results reported as follows :—

	Value of produce *minus* cost of cultivation		
	Rs.	a.	p.
T_1 Fallow, wheat	29	2	4
T_2 *Urid* green-manured, wheat	22	6	7
T_3 Soybean green-manured, wheat	23	7	4
T_4 Sann-hemp green-manured, wheat	35	4	9
T_5 Sann-hemp tops buried, fibre extracted from stems, wheat	30	8	3

As the experiment will run for some years and is on a statistical basis, no comments need be made at present.

The experiment on growing Mexican sunflower (*Tithonia diversifolia*) with onions and burying the Mexican sunflower for green-manuring was carried out on comparatively poor land this year. The results show that the control plots with onions alone yielded on an average 89 maunds per acre, while the plots with onions and Mexican sunflower yielded 51·6 maunds onions per acre and 230 maunds of sunflower per acre. This quantity of sunflower would suffice to manure one acre of land. It remains to be seen whether yields obtained in subsequent crops would compensate for the loss in onions. Previous year's results on richer land have shown that the loss in onions is more than compensated by the gain in yields of subsequent crops.

Nitrification

The experiment started to find the seasonal effect on the nitrifying flora in soil taken from the field and kept in the laboratory was continued. It was found that in the field there are generally two principal periods of depression of nitrifying flora in May and October or November due to sudden rise and fall in temperature respectively. Other slight variations occur during the rainy season or whenever there is a change in moisture content of the soil. In the laboratory sample the depression of the nitrifying flora occurs in May and January. The depression due to cold occurs later in the laboratory than in the field probably because the change in the temperature in laboratory occurs later. As the moisture content

in the samples kept in the laboratory remains constant no change due to variation of moisture is observed as is found in the field samples in the rainy season.

The examination of samples of soils taken once a month from the permanent manurial experimental plots Nos. 3, 10, 12, 13 and 16 in the Punjab field was continued throughout the year. The samples obtained in January, May and September were found to nitrify ammonium sulphate and cake more quickly (within 4 weeks) than the samples taken in other months which took 6 to 8 weeks to show maximum nitrification.

The bacterial counts as found by plating were highest in farmyard manure, complete minerals and green-manure plots in August, while the green-manure *plus* superphosphate and the no manure plots showed the highest counts in December and January respectively. Samples of soils taken from these plots in May 1932 before the rains and just after the rains showed that bacterial plate counts in samples taken before the rains were greater than in the samples after the rains, showing that a large number of bacteria are washed down by the rains. The nitrifying power also showed a great decrease after the rains. This is well brought out by calculating the percentage of nitrogen nitrified in Omelianski solution in 8 weeks when the inoculum was in the form of soil extract equivalent to 1 mg. of the soil.

	Per cent. nitrogen converted into nitrates in 8 weeks	
	Samples before rains	Samples after rains
Farmyard manure	85·0	4·0
Complete mineral	70·0	5·0
Green-manure	20·0	4·0
No manure	12·0	10·0
Green-manure *plus* superphosphate .	20·0	6·0

No such variation was observed in nitrogen-fixing power in the samples taken before the rains and after the rains when inoculated in Ashby's mannite solution. The results obtained lead to the conclusion that probably the rains wash down the nitrifying and ammonifying organisms to lower depths but not the nitrogen-fixing organisms.

In previous years it was found that calcium cyanamide was converted into nitrate when added to many Indian soils after about 12 to 20 weeks, but in seven soils it took more than 20 weeks for the formation of small amounts of nitrates from cyanamide, although ammoniacal nitrogen was found in fairly large amounts

much earlier, *i.e.*, after a short period of incubation for two or three weeks. As the nitrification was completed later in most of these seven soils without resorting to inoculation of nitrifying organisms, it was inferred that the amount of toxic bodies like dicyandiamide formed during the decomposition of cyanamide in these soils could not kill the original nitrifying flora present in the soils. Experiments were, therefore, carried out to find what concentration of dicyandiamide is toxic to nitrifying organisms by addition of varying quantities of pure dicyandiamide to Omelianski solution inoculated with a culture of nitrifying organisms. It was found that a concentration of dicyandiamide equal to 5 and 10 mg. in 100 c. c. solution had practically no effect on the activity of the nitrifying organisms, but a concentration equal to 25 mg. per 100 c. c. retarded and sometimes inhibited the activity of the nitrifiers. Attempts were next made to see whether the extracts of these soils after incubation for two weeks with addition of cyanamide when no nitrates are being formed have a toxic effect on the nitrifying culture in Omelianski solution. It was found that soil extracts equivalent to 25 mg. in 100 c. c. as dicyandiamide (assuming, of course, that the whole of the calcium cyanamide, which had disappeared from the soils, had been converted to dicyandiamide) did not have any toxic effect in the nitrifying cultures. The soil remaining after extraction, however, showed a decided toxic action on the nitrifying flora. It is concluded, therefore, that in these soils either dicyandiamide is not formed or if formed the concentration is not sufficient to be toxic to nitrifying organisms but the calcium cyanamide is converted into some compound, toxic to nitrifiers, which is not water soluble and is retained in the soil. This compound is brought into solution when the soil is treated with dilute hydrochloric acid and can give off ammonia when distilled with magnesia. Attempts are now being made to follow the course of decomposition of cyanamide in these soils by determining dicyandiamide, urea and the insoluble nitrogenous compound formed in the soil. The chemical methods to be used for determining dicyandiamide, cyanamide and urea were standardised for the determination of the small quantities of these compounds formed in the soils after the addition of cyanamide.

Bacterial analysis of soils under irrigation and under dry farming conditions was continued by taking samples at different depths down to 36 inches, and the number of bacteria as observed by plating and the total nitrogen continued to be higher in the irrigated plots than in the unirrigated plots. The nitrifying organisms have become more active since the experiment was started in 1931 but there is not any marked difference in the ammonifying, nitrifying and nitrogen-fixing power of the soil between the irrigated and unirrigated samples. The change in these activities is comparatively slower than in the total number of bacteria and the total nitrogen in the soil.

THE AZOTOBACTER SOIL PLAQUE TEST FOR DETERMINING FERTILIZER REQUIREMENTS OF SOILS

It is well known that the bacterial activity in the soils depends on the presence of sufficient nutrient materials and other favourable conditions. Advantage is taken of this fact in devising bacteriological methods for examining the deficiencies of soils. One of the group of organisms chosen for the purpose is the azotobacter group of nitrogen-fixing organisms, which is very sensitive to acidity and lack of available phosphate in the soil. The method devised by Christensen and Niklewski consisted in finding the lime and phosphate requirements of soils by inoculating the soil to be examined in mannite solution and noting the azotobacter growth. These conditions of growth were considered unnatural by Winogradsky who has developed a method termed *la method des "Plaques moulees"* or the kneaded soil plate method for directly examining the azotobacter in the soil itself. This method has been modified by other investigators and it has been claimed that it can be applied to detect the potash and phosphoric acid requirements of a soil in a very short time.

The technique consists in adding 5 per cent. starch to the soil and dividing it into 4 lots. No. 1 serves as control. To No. 2 is added 2·5 c. c. of a 3 per cent. solution of potassium sulphate, to No. 3 is added 2·5 c. c. of a 6 per cent. solution of Na_2HPO_4 and to No. 4 is added 2·5 c. c. of a 3 per cent. solution of K_2HPO_4. These amounts of the salts to be added have been reported to be the optimum to produce good results. The requisite amount of water is separately added to each lot to form a paste which is well kneaded. On a moistened glass plate, the kneaded soil plaques are placed one by one and pressed by the hand to form cakes which are then transferred to a petri dish kept in a moist chamber and incubated for three days at 30°C. Moist glistening colonies of azotobacter make their appearance on the surface of those cakes which supply the requisite nutrients. When a good growth occurs on all the cakes the inference is that the original soil contains sufficient amounts of potash and phosphoric acid. If growth occurs only on the second and fourth cake the inference is that the soil is lacking in potash. If it occurs on the Na_2HPO_4 and K_2HPO_4 cakes, then the soil is deficient in phosphoric acid, while if the growth occurs only on the K_2HPO_4 cake then the soil is deficient in both potash and phosphoric acid.

In case the soil is acid with a pH index 6·5 or less lime will have to be added to neutralize acidity and in some cases where the soil is lacking in azotobacter cells a culture of the organism will have to be inoculated into the soil.

Eight Indian soils of varying pH and physical texture were subjected to this test to find out whether any definite indications

are obtained about their deficiencies of potash and phosphoric acid. The results are given in the following table :—

	Gujranwala	Pusa no manure	Kulanpur	Sialkot	Krishnagar	Chinsurah	Ranchi	Dacca
pH . . .	8·1	7·3	7·3	7·3	7·3	7·2	6·0	5·9
Control . .	O	O	O	OF	+F	OF	O	O
K_2SO_4 . .	O	O	OF	OF	O	O	O	O
Na_2HPO_4 . .	+++P	+	++	++++P	++	+++P	O	OA
K_2HPO_4 . .	+++	+++P	++++P	++++P	++++P	+++P	O	AO

O = No azotobacter
+ = Slight growth of azotobacter
++ = Moderate growth of azotobacter
+++ = Fair amount of growth of azotobacter
++++ = Numerous colonies
P = Black pigmentation
F = Fungus growth
A = Actinomyces

From the above it is seen that none of the soils tested except Krishnagar show the growth of azotobacter in the kneaded cakes without treatment (control). The addition of K_2SO_4 does not improve matters in any case. The response to K_2HPO_4 is clearly indicated in all soils except Dacca and Ranchi which are acidic. The response to Na_2HPO_4 is less marked than that of K_2HPO_4 although none of the soils show potash deficiency by responding to an addition of K_2SO_4. The conclusion, to be drawn from these results, according to the originators of the method, is that all the soils examined are lacking in phosphate. We must not, however, lose sight of the fact that there is also the possibility of the test not being sensitive enough to distinguish between the varying degrees of phosphate requirements of the different soils. Further trials were therefore done with soils taken from the permanent manurial plots in the Punjab field experimental area at Pusa. These plots have been receiving the same manures continuously

for the last 20 years or more and should show good growth of azotobacter in soils manured with superphosphate. In this experiment only one treatment with the addition of K_2HPO_4 was tried.

	No manure	Farm yard manure	Green manure	Complete minerals	Potassium Sulphate.	Superphosphate	$(NH_4)_2SO_4$	Green manure and super
Control. .	0	+	0	+	0	+	0	0
K_2HPO_4	++++	+++++P	++++P	++++P	++++P	++++P	++++P	++++P

Here again a more vigorous growth of azotobacter with the addition of K_2HPO_4 than in the control cakes is seen in all the soils including the soil from the plot treated with superphosphate for 20 years showing that even with this treatment the phosphate in the soil is not readily available for azotobacter.

The marked effect of potassium phosphate on azotobacter led to the suggestion that it may be possible by the use of this method to distinguish between the availability of phosphates of the different phosphatic fertilizers when added to any particular soil. So the following phosphatic fertilizers—(1) Superphosphate, (2) Trichy nodule, (3) Bonemeal solubilized by sulphur-oxidising bacteria in a compost, (4) Bone dust prepared by treating bones with alkali, (5) Powdered apatite called Kudada phosphate, (6) Calcium phosphate (Merck)—were added to four different soils to see the effect of these fertilizers on azotobacter growth. 0·3 grm. of each of the fertilizers was added to the plaques of different soils which were then incubated for three days at 30°C. The results are given in the following table :—

Fertilizer	Pusa soil	Chinsurah	Sialkot	Ranchi
Superphosphate	OF	++F	++F	OF
Trichy nodule	++	+F	+++P	O
Solubilized bonemeal . . .	+++P	+FF	+++P	O
Bone dust fine	++*	*++F	*++P	O
Kudada phosphate . . .	O	OF	O	O
Calcium phosphate (Merck) . .	+++P	++P	++++P	O

*—Appearing slowly

Superphosphate is the usual phosphatic manure used and is considered the most easily available to the crops. As used here, it shows the peculiar characteristic of giving a growth of fungi in all the soils but azotobacter colonies only in two. This behaviour may probably explain the encouragement of fungal attacks of crops on the addition of superphosphate to some soils and incidentally also the fixation of the soluble phosphate in an insoluble form into mycelium of the fungi growing in the soil to which superphosphate has been added. The apatite "Kudada phosphate" does not appear to be available to azotobacter in any of the soils. All the other phosphatic fertilizers appear to be more or less available in three soils. In Ranchi soil, none of the substances gives a growth of azotobacter. This is what is to be expected as it is an acid soil with a pH index 6·0. Incidentally it may be pointed out that though originally not intended for finding the lime requirements of an acid soil, this method can furnish the information if cakes of the soil with 5 per cent. starch + 0·3 per cent. K_2HPO_4 are made with varying amounts of lime and the growth of azotobacter noted on them. The cakes after exact neutralization and further additions of lime would show azotobacter colonies and thus give an idea about the probable lime requirements of an acid soil.

Phosphate solubilization

A sample of apatite called Kudada phosphate was composted with greeen manure, sulphur and charcoal to see whether the insoluble phosphate contained in it could be made available to the crops. The composts made did not show any great increase in soluble phosphate. This is ascribed to the large amounts of iron oxides contained in it, as even treatment with strong sulphuric acid failed to make more than 11 per cent. of the total insoluble phosphate citrate-soluble. Pot and field experiments with the Kudada phosphate by itself and the acid treated Kudada phosphate have shown that although wheat is not benefited by the application of these, other crops like *Eleusine coracana* and mustard give an increased yield with the application of the treated and the untreated apatite. The tentative conclusions are that too much reliance cannot be placed on the chemical analysis of the phosphates, that certain crops are able to extract their phosphoric acid requirements from comparatively insoluble salts and that the presence of SO_4 ions helps to make the insoluble phosphates available to the crops. Composting the apatite with sulphur and green manures is likely to solve the problem of utilization of this apatite. Large-scale field experiments are necessary to place these conclusions on a firmer basis.

IV. BACTERIOPHAGY

The bacteriolytic principle capable of dissolving the suspension of root nodule organisms isolated from berseem root nodules was

tested for the number of types of bacteriophage present in it by the method used by Dr. Asheshov, and it was found that there is only one type of bacteriophage. After establishing the single type of bacteriophage, it was tried on cultures of nodule organisms from *Lathyrus odoratus*, which were found to be susceptible to its action showing that the bacteriophage of the berseem nodule organisms can act on cultures of some other nodule organisms also.

Dissociation. One of the chracteristics of the colonies of a culture of the organism *B. cereus* is that it shows pellucid dots resembling plaques caused by a bacteriolytic principle. As the attempts to separate the bacteriophage from the culture of organisms were not successful, it was suggested that the plaque-like appearance may be caused by the dissociation of the organism into different types. A liquid culture of *B. cereus* which is a spore-former was therefore purified by heating the culture to 100°C. in a steamer so as to kill the vegetative forms. From the spores remaining in broth, a fresh culture was obtained by inoculation into a broth tube which was again subjected to a temperature of 100°C. to get a fresh culture from the spores. After repeating this process ten times, a culture was finally obtained which was successively inoculated and passed through series of broth tubes of increasing alkalinity and acidity to observe whether it dissociated into different types, adapted to different hydrogen-ion concentrations. The culture was also transferred through successive broth tubes containing 0·25 per cent. lithium chloride to enforce dissociation more quickly as was attempted by Hadley and others. From both the series of broth cultures when plated, after a series of transfers, two forms could be obtained, a yellow short rod and another white coccal rod, the latter being obtained more frequently than the former. It appears, therefore, that the pellucid dots observed in the cultures of *B. cereus* are the result of the dissociation of the cultures into two types. The cultural characteristics of these two types were tested and found to be different from those of the culture of *B. cereus*. The culture of *B. cereus* used in our experiments was first isolated from the tomato plants affected with mosaic and from the soil in which the mosaic plants were growing. Afterwards *B. cereus* was also isolated from Krishnagar soil in which tobacco plants affected with mosaic were growing.

Filterable forms of bacteria. It was found on many occasions that secondary growths occurred in the filtrates of liquid media cultures of the root nodule organism and *B. cereus* after passing the cultures through L_3 filter candles. The secondary cultures obtained were not due to contaminations from outside organisms but in both cases proved to be the cultures of the orginal organism filtered. The candles were tested by the air pressure method and were found to be bacteria proof. It was inferred, therefore, that the secondary growths were due to filterable forms of cultures passing through the candle. By filtering the cultures of different ages (from 1 day

old to 1 week old cultures) it was found that filterable forms which give secondary growths in the filtrates are present in the first three or four days. After that time the filterable forms become stabilised and secondary growths or reversion to visible forms in the filtrates of a week's old culture is very rare. By using the technique employed by Hauduroy to get a visible growth from the filterable forms, however, it has been possible to make the stable filterable forms in the filtrates of old cultures revert to visible forms after 4 or 5 transfers of the filtrate on solid agar media. These observations on the filterable stage of two soil bacteria are of importance and have a direct bearing on the study of number and activity of organisms present in the soil.

V. DAIRY BACTERIOLOGY.

The average plate counts of the bacterial content of milk supply are given below with those of the previous two years for comparison :—

Months	Average counts per c. c.			Days present in 1/100 c. c.	Coli counts 1932-33	
	1930-31	1931-32	1932-33		Days absent in 1/100 c. c.	Days present in 1/10 c. c.
July 1932	5,500	3,833	5,225	4	8	12
August	4,400	4,092	7,857	4	11	10
September	6,700	4,753	10,575	6	6	10
October	2,840	2,333	13,760	2	4	4
November	5,400	3,490	7,713	6	9	6
December	1,840	3,400	4,098	4	5	4
January 1933	2,200	8,825	6,508	12	0	12
February	2,900	4,000	3,617	9	4	13
March	3,565	9,750	5,071	2	12	9
April	3,472	8,617	3,717	1	11	3
May	3,900	5,871	5,127	3	12	10
June	2,664	7,192	8,283	2	10	9

The counts of the year were higher than those of the previous years for the first five months and the last month but for the remaining six months they were lower despite no change in hours of milking and milk distribution. The probable explanation of this rise in bacterial counts in the same season in alternate years is that the milk of certain individual cows whose lactation period occurs in alternate years has a high bacterial count and therefore leads to higher average counts.

B. coli were found on more occasions than in the former years and were present in high numbers in the cold season especially January and February 1933. Attempts were made to locate the source of these unusually high counts in the cold season. The churns and buckets were free from *B. coli* but the funnel and the pipe through which the milk is passed to the weighing room were found to be the source of this contamination. When examined separately the funnel was also free and only the pipe was involved. Treatment of the tube with catadyn water proved effective but *B. coli* reappeared after two days. Even after sterilization in the autoclave *B. coli* again appeared after a short interval of two or three days. The method of washing the pipe with sodium carbonate was suspected to be not quite effective at the lower temperatures in the cold season, a microscopic film of milk with *B. coli* developing in it being probably retained on the inside of the pipe. A second washing of the pipe at the time of steaming was, therefore, suggested and proved effective. From March the coli counts went down.

A comparison made between Erb's and Newman's stains for smears of milk used in counting the numbers of bacteria by direct examination under the microscope showed the latter stain to be superior, as it gave a more highly stained background with the organisms more distinctly visible than the former could give. Also there was neither precipitate nor fat globules to be seen in the smear with Newman's stain which has the following composition :—

Certified methylene blue	1·0—1·2 grm.
Absolute methyl alcohol (ethyl alcohol 95 per cent. may also be used)	54 c. c.
Technical tetrachlorethane	54 c. c.
Glacial acetic acid	6 c. c.

Starters for butter making

While studying the lactic acid organisms present in *dahi*, it was observed that none of these develop a pleasant aroma in the butter made by using cultures of the *dahi* lactic acid bacteria for ripening the cream. A number of strains of lactic acid organisms were isolated from dairy milk and commercial butters

under different conditions of storage and were tested for their ability to produce volatile acid in milk and in milk plus citric acid. Only one strain has so far been isolated which produces volatile acid equivalent to 24·7 c. c. of N/10 alkali from 1000 c. c. distillate obtained from 250 c. c. of milk without addition of citric acid and volatile acid equivalent to 43·9 c. c. of N/10 alkali with addition of citric acid. Hammer from one of his satisfactory cultures of aroma producers in butter has obtained the following figures, 23·5 c. c. without citric acid and 63·5 c. c. with citric acid. This strain of organism isolated appears to be similar to *Streptococcus citrovorus* or *paracitrovorus* of Hammer or *Betacoccus cremoris* of Orla Jensen but all these latter organisms studied by Hammer and Orla Jensen do not coagulate milk at 20°C. while the Pusa strain is found to coagulate milk at 20°C. As this characteristic may prove to be an advantage in the use of the Pusa strain, because a single culture of this strain may be useful in ripening the cream by production of aroma combined with sufficient acidity, three large-scale experiments on cream ripening with this aroma-producing organism and other lactic acid organisms were carried out at the Bangalore Institute of Dairying and Animal Husbandry and the butter manufactured was submitted for examination of flavour to the Imperial Dairy Expert. Among the single organisms tried, the aroma-producer isolated at Pusa was easily placed first for making butter for table use in all the three tests, while compared with the cultures of mixed organisms as against the Pusa strain used singly, it stood second to a mixture of the Pusa strain with another strain of the *Streptococcus citrovorus* and *paracitrovorus* group of organisms. For keeping quality or commercial use a triple mixture of this organism and another strain of the *citrovorus* group with the *Streptococcus lactis* was found to be better, because this mixture develops flavour combined with acidity sufficient to keep the butter from deteriorating during storage.

VI. SILAGE

Recently Dr. Virtanen has devised a technique by which he claims preservation of grass in the form of silage without fermentation and with an insignificant loss. The attainment of the correct pH value by the addition of some acid is the essential feature of the method. A patented acid mixture is used in such quantity that it increases the original hydrogen-ion concentration of the fodder to pH index 4. A preliminary experiment was made to find out the quantity of hydrochloric acid which when mixed with berseem will bring the mixture to the pH index 4. The acid required was found to be 1 per cent. This quantity was considered to be uneconomical for ensiling berseem. Attempts were, therefore, made to see whether berseem could be preserved with lower concentrations

of hydrochloric acid. Quantities varying from 0·1 per cent. to 1 per cent. of hydrochloric acid were added to berseem in different jars and the nature of the silage, its pH index and palatability to cattle were tested. The different silages obtained were well preserved with all the treatments but those with 0·4 per cent. and higher amounts of acid were not touched by cattle, while those in which 0·1 per cent. to 0·3 per cent. acid was added were much relished.

A pit was filled with berseem by the Imperial Agriculturist to see the effect of the addition of 0·1 per cent. hydrochloric acid, the least amount found suitable in the laboratory. After two months the pit was opened and the silage fed to cattle. Twenty seers was given to each animal, and it was eaten readily. No bad symptoms were observed after feeding in any of the animals. The pH of the pit silage was 5·4, the same as that for the laboratory silage with the same concentration of acid, and the total acidity was 6·0 per cent. on the dry basis.

Use of molasses in silage

Attempts were made to see whether molasses could be used for mixing with green fodder for turning it into silage. As the chief advantage of the addition of molasses lies in supplying soluble carbohydrates and in increasing the acidity by stimulating the activity of lactic acid organisms, it was considered advisable to use such fodders as do not develop much acidity when used by themselves, so that fodders unsuitable for silage by themselves could be utilized. Berseem, kudzu (*Pueraria thunbergiana*), *dub* (*Cynodon dactylon*) grass and a mixture of different grasses from the lawn, all of which had not previously given good silage by themselves, were, therefore, selected for turning into silage with the addition of molasses and wheat straw and pH and the total acidity on dry basis were determined at intervals. Acidity was found to develop more quickly after the addition of molasses in all the fodders. The highest amount of molasses added was 10 per cent. of the fodder to be ensiled and developed an acidity of about 17 per cent. on a dry basis. The silage had a pleasant odour, none of the fodder material ensiled by themselves showed any increase in acidity, berseem silage being distinctly alkaline. The silages made from berseem and the mixture of lawn grasses without the addition of molasses or wheat straw, developed a bad odour, while the *dub* grass and the kudzu silages had not a particularly bad odour but neither it could be described as fine. The results of these experiments show that a great advantage would result from the addition of about 10 per cent. molasses to some fodders at the time of ensiling them, and this work will be continued.

VII. POTATO STORAGE

In the storage experiments, country potatoes were not much damaged whether stored with or without charcoal and there was only a slight advantage in favour of storage in charcoal. Country potatoes grown after application of different manures were stored in March 1932 to see the effect of manuring on the keeping quality of potatoes. The potatoes were stored with and without charcoal in all cases. There was a slight difference in favour of charcoal but as only 8 per cent. is the maximum damage due to rotting in storage, no distinction could be made between the effects of different manures.

Hill potatoes were grown under irrigation and stored with and without charcoal with the following results :—

	Non-irrigated		Irrigated	
	Without charcoal	With charcoal	Without charcoal	With charcoal
Per cent. sound tubers recovered .	5·2	53·0	28·1	84·2

It appears that hill potatoes are more liable to damage under storage conditions in the plains. Storage in charcoal helps to prevent 45—55 per cent. damage. Irrigated potatoes keep better in storage than the unirrigated ones. This is due probably to the fact that a greater number of the tubers in the irrigated crop are comparatively more immature than in the unirrigated crop and immature tubers keep better than the mature ones, as it has already been observed in our previous experiments that the crop harvested earlier, and so consisting of more immature tubers, is better able to withstand storage conditions than the crop harvested later.

VIII. PLANT DISEASES

Cauliflower crown rot. Three kinds of bacteria were isolated from the rotting crowns of cauliflower and inoculations were carried out with the cultures. One culture which produced the typical symptoms on inoculations was studied further and was identified as *Bacterium campestris* (E. F. Smith).

Leaf stripe of juar. A disease of *juar* (sorghum) received from the Millet Specialist, Coimbatore, was identified as the leaf stripe disease of sorghum caused by *Bacterium andropogoni.*

Wheat ear cockle. Diseased wheat ears received from the Agriculturist at Sakrand farm, Sind, contained numerous bacteria in the grain of the ears, although no nematodes were found to emerge from the ear cockle galls. The disease appears to be similar to the ear cockle caused by *Bact. tritici*, gaining entrance after the attack by the nematodes.

Tobacco disease from Krishnagar.—Healthy and diseased specimens of tobacco plants from the same field were received from Krishnagar farm. Three kinds of bacteria were isolated from the diseased specimens but none of them resembled *B. solanacearum*. The soil surrounding the roots of the diseased and healthy plants was plated and gave a number of bacteria among which was observed *B. cereus*. As this organism in the soil has been found to be associated with tomato mosaic, it was suspected that the wilting might be due to tobacco mosaic. Inoculations were, therefore, made from diseased leaf tissues. Some of the plants inoculated with leaf tissues showed distinct signs of mosaic after five or six days.

Yellowing of canes. A peculiar yellowing of canes in the Saran District appeared after the heavy rains in July 1931 and 1932. The leaves turned yellow from tip downwards and later reddish streaks and spots made their appearance on the leaves. Generally the fourth or fifth leaf from the top first showed signs of turning yellow. Yellowing sometimes appeared in the third leaf from the top. Healthy and diseased canes appeared in the same clump. The disease could not be definitely associated with any insect, fungus or bacterial attack. Examination of the roots of diseased and healthy canes showed that in the healthy canes a fresh flush of roots was thrown out regularly from upper nodes when the old ones had begun to weaken and die, but in the yellowing canes there was a scarcity of new roots at the upper internode, showing that the yellowing canes had received some check in its growth. To trace the cause of this check in growth, the soil round the diseased and healthy clumps from several places was collected and examined for nitrates, ammonia and alkali salts but no appreciable difference could be detected. Analyses of leaves from diseased and healthy clumps from different patches of yellowing clumps showed that the diseased yellowing leaves were comparatively poorer in almost all the plant foods. There was more starch accumulated in diseased leaves than in healthy leaves. An examination of the extract of leaves for enzyme activity showed that the yellowing leaves had equal or sometimes greater enzyme activity in hydrolysing starch than the healthy leaf extract, but somehow it was unable to hydrolyse the starch in its own extract. It may be suggested that probably a lack of some substance in the extract of leaves from yellowing canes prevented hydrolysis. This substance could be provided by properly manuring the yellowing clumps, so some

experiments were made on manuring the yellowing clumps with potassium sulphate, gypsum, ferrous sulphate, magnesium chloride and ammonium sulphate, and it was found that clumps manured with either potassium sulphate or ammonium sulphate to a certain extent revived and assumed a healthy appearance.

Water culture experiments showed that the variety Co. 213 which is the one greatly affected is likely to show yellowing in the absence of potassium or nitrogen.

It is concluded from these different experiments that yellowing of canes is a deficiency disease caused by the absence of sufficient amount either of potassium or nitrogen in the soil. A scheme of experiments has been drawn up to decide this point, but as a practicable measure it may be suggested that an extra dose of organic manure like oil-cake containing all the plant foods may be applied to the canes at the time of earthing up on the basis of 50 lb. of nitrogen per acre to such fields as have shown yellowing in past years, and also to those which are showing signs of yellowing for the first time.

IX. PROGRAMME OF WORK FOR 1933-34

Conservation of nitrogen in soil. Conservation of nitrogen is one of the important problems in maintaining the fertility of Indian soils. A series of experiments of growing leguminous crops in mixtures or rotation were started three years back : one adapted to the *kharij* season and the other to the *rabi* season. These will be continued and the variations in total nitrogen in the soil and the economic returns of crop will be examined.

Green-manuring. The large-scale experiment will be continued of comparing *urid* and soybean and the application of sann-hemp tops late in the season after removing the stems for fibre, with the usual method of ploughing in sann-hemp. The experiment with Mexican sunflower will be repeated and a large-scale experiment tried on the farm.

Biological analysis of soils. Biological analysis of the samples of soil from irrigated and unirrigated fields will be continued to find what changes irrigation produces. Biological analyses of other soils will be carried out as occasion arises.

Calcium cyanamide. The decomposition products of calcium cyanamide in different soils which nitrify calcium cyanamide much later than in other soils will be studied.

Bacteriophagy. Search for the bacteriophage from roots of cereals will be continued and they will be studied after their isolation to find what effect they have on the leguminous nodule organisms in soils.

Dairy bacteriology. Quantitative study of bacteria present in general milk supply at Pusa at the time of distribution and in individual cows with a view to bacterial control of cleanliness in production of milk in the dairy will be continued. Study of starters producing flavour in butter will be continued. Observations on the kind of coli present in milk supply will be made.

Bacteriology of silage. Preparation and study of silage from different fodders with the addition of wheat *bhusa* and molasses will be continued. Study of treatment of fodders with hydrochloric acid for their preservation as in A. I. V. process will be continued.

Other investigations. Study of the preservation of fruits and vegetables by cold storage and the effect of spices in pickles in preventing spoilage will be carried on.

X. PUBLICATIONS

Desai, S. V. The influence of Green Manure and Organic Residues on Nitrogen fixation in Soil. *Ind. Jour. Agri. Sc.*, Vol. III, Part II, April 1933.

———Studies on the Nature of the Causative Agent of the Mosaic Disease of Tomatoes. *Ind. Jour. Agri. Sc.*, Vol. III, Part IV, August 1933.

REPORT OF THE IMPERIAL DAIRY EXPERT

[Zal R. Kothavala, B.Ag., B.Sc. (Agri.), N.D.D.]

I. INTRODUCTION

I held the post of the Imperial Dairy Expert throughout the year.

Due to the acute financial crisis which had arisen before the beginning of the year under review it was found necessary to reorganize the working of the farms under the control of the Imperial Dairy Expert with a view to effect reduction in the budget demands of this Section. Some of the salient features of the reorganization were that the commercial activity of the dairy farm at Bangalore was curtailed, experiments in cross-breeding with European cattle to establish a cross-bred herd were abandoned and attention was concentrated on the breeding of high yielding strains of indigenous breeds, while the Wellington farm was maintained solely as a milk producing depot, cows in milk being supplied from Bangalore as required and returned when dry. The total strength of the herd at the Imperial Cattle Breeding Farm, Karnal, was reduced to 400 head of cattle and the ' home cultivation ' at this farm was reduced to a minimum, the remaining land being let out on cash rental and *batai* systems to reduce the cultivation expenses to the minimum possible.

All the three farms at Bangalore, Wellington and Karnal were maintained mainly on the same lines as in the past, *i.e.*, as quasi-commercial concerns with education and scientific investigations as their primary functions. The commercial activities of the farms for the year yielded a profit of Rs. 40,509 against a loss of Rs.11,478 last year. The financial position of the farms had never been so favourable before. Various factors contributed in bringing about such a favourable result but the biggest contribution came from the farm staff who worked whole-heartedly to cope with a difficult situation.

In spite of the adverse financial conditions prevailing throughout the country, the demands made on this office for technical advice and instruction connected with the dairy industry from all parts of India from the general public, associations, municipalities and Provincial Governments were on the increase. This advisory work and the training constitute two of the most important and indispensable portions of the activities of this Section for the advancement of the dairy industry in India. Several requests were received for help for educational and propaganda work on dairy matters from Health Week Committees, Baby Shows, Agriculture and Dairy

Exhibitions, etc., which indicate that there exists an immediate necessity for active propaganda in favour of known methods of improvement in all phases of the dairy and dairy products industry and in animal husbandry in India. The interest evinced by the public in these matters is also indicated by the large number of interested persons who visited the Bangalore Dairy Institute during the year.

The Dairy Institute received a gift from Messrs. Edw. Keventer, Aligarh, of a complete plant of an Alfa Laval Magneto Milking Machine presented by the famous Alfa Laval Co., of Copenhagen, for instructional purposes.

The year proved favourable from the point of view of weather conditions as all the farms reported good and timely rains and although the acreage under cultivation remained the same, increased yields of crops were obtained. Better value was also realized by the sale of farm produce at Karnal due to the market rates remaining favourable. The contrary was the case with the disposal of dairy produce at all the farms.

The condition of the cattle at all the farms remained very satisfactory, there were fewer outbreaks of diseases and the farm at Wellington was particularly free from it. The Karnal farm continued to maintain the two herds of the Hariana and Tharparkar breeds, and with systematic selective breeding it has now been possible to attain a record of over 8,000 lb. of milk per lactation. The record for fat so far obtained is as high as 7·8 per cent. At the Bangalore farm the herd of Red Scindis is gradually being built up and a new foundation herd of the Gir breed was started this year. The policy followed in breeding these two herds is on pure line selection to obtain high milk yielding strains of these breeds. Along with the maintenance of other breeding records the systematic recording for fat for each individual animal has been started from this year and this should in course of time yield very valuable information.

II. TRAINING AND EDUCATIONAL WORK

The fifth group of 19 students of the Indian Dairy Diploma course admitted in October 1931 continued its training during the year and had terms at the farms at Karnal, Wellington and Bangalore. One repeat-course student was admitted on the 5th June, 1933.

One post-graduate student who had left the course on the 12th August, 1931, was readmitted on the 6th July, 1932, and completed his training. One more post-graduate student was admitted on the 3rd February, 1933.

Short courses of practical training in different branches of dairying, varying in periods from two to six months, were given at the farms at Bangalore and Karnal to three students from private dairies and Indian States.

Twenty-eight British soldiers were given vocational training during the year in practical dairying and 15 more British soldiers were admitted on 1st June, 1933, for a similar course of training.

An examination of the Dairy Diploma course was held in December, 1932, at the Allahabad Agricultural Institute and out of 10 students who sat for the examination 8 passed, one with honours.

III. EXPERIMENTAL AND RESEARCH WORK

Bangalore. The development of the Scindi breed by selective breeding to produce a high milk-yielding strain has been continued. The same nature of work has been started on another Indian breed, the Gir, by founding a small herd this year.

The work on the weaning of calves at birth for Indian breeds and their economic hand-rearing is being continued.

An important experiment on the feeding of dairy cows has been started with the assistance of the Physiological Chemist, *viz.*, the effect of feeding of rations with a high protein content to dairy cows on the quantity and quality of milk, lactation period, body weight, heat period, subsequent calving, etc.

In addition, experimental work was carried out on—

Feeding of bone-meal to Scindi cows to see whether that would cause the animals to come in heat earlier after calving or prevent repetition of services ;

Manufacture of experimental cheeses to demonstrate the effect of varying percentages of fat in milk on the quality and yield of cheese.

Wellington. The following investigations are being conducted—

(1) Effect of feeding bone-meal on occurrence or recurrence of oestrum.

(2) Daily variations in fat per cent. of milk of individual cows during lactation.

(3) Effect of feeding lucerne on milk yield.

(4) Sex ratio of calvings in relation to advancement of heat at the time of service.

(5) Collection of statistics from old records pertaining to—

(*a*) Mortality among calves in rearing them on the " weaning system ".

(*b*) Proportion of male or female calves born.

(*c*) Effect of heat on yield of milk.

Karnal. The breeding experiments on the Hariana and Tharparkar breeds of cattle on the same lines as last year were continued. Both breeds have risen in milk yield and records of over 8,000 lb. per lactation have been obtained. By the system of recording fat percentage of individual cows which was started this year, it has been found that Indian breeds can yield as high as 7·8 per cent. fat, whereas instances of animals giving 6·5 per cent. fat are quite common. The weaning of calves at birth and their hand rearing is being continued.

An experiment on the feeding of rice and wheat straw to young stock was started with the help of the Physiological Chemist to determine the comparative feeding value of these roughages.

In addition the following investigations were carried out :—

(1) Trial of hormone injections on animals for accelerating the heat.

(2) Recording of butter fat tests of individual cows of Tharparkar and Hariana breeds.

(3) Testing of samples of bazar milk for fat contents for comparison with the Karnal dairy standard.

In addition to the aboveenumerated work at the three farms, the following investigations were undertaken by the post-graduate students at Bangalore and Karnal :—

(1) Determining the keeping quality of milk after pasteurisation and re-pasteurisation.

(2) Increase in the body weight of dairy cows in relation to their fœtal development.

(3) Milk yield in relation to calving intervals in dairy animals.

(4) Efficiency of milk production in relation to size in the case of dairy cows.

(5) Relation of the weight and size of calf at birth with that of its dam and sire.

(6) Seasonal variations in the quantity and quality of milk in the case of Hariana and Tharparkar herds at Karnal.

(7) Observations on the correlation between the red and grey shades of colour and the milk yielding capacity in the case of Hariana and Tharparkar breeds.

IV. PUBLICATIONS OF THE YEAR

Articles sent for publication were—

(1) " Observation on the regularity of breeding in the case of cows of the Hariana and Tharparkarbreeds ", by Mr. C. N. Dave, Post-graduate student.

(2) " Determination of Live Weight of cattle by measurement ", by Mr. Sodhi Gambhir Singh.

V. CO-OPERATION WITH OTHER SECTIONS AND DEPARTMENTS

This Section fully co-operated with the Physiological Chemist's Section in providing it with the facilities required for its experimental work in the form of cattle, fodder, feeds, etc. The co-operation received from that Section in the starting of important experiments, advice on feeding matters and in the training of students is very much appreciated.

The Botanical Sub-Station at Karnal was offered help in trying their wheat varieties on a field scale.

The Veterinary Research Institute, Muktesar, was provided with animals and other facilities for trying the experiment on immunization against rinderpest by the direct goat virus method.

VI. ADMINISTRATION OF FARMS

The following detailed reports from the Superintendents of the farms regarding the administration of the farms are submitted. The main features regarding the working of these farms have already been commented on by me in the introductory paragraph to this report :—

Karnal

Mr. A. Lamb was in charge of the farm up to 28th March, 1933, and Mr. M. C. Rangaswamy held charge of the current duties of the office of the Superintendent for the period 29th to 31st March, 1933.

The market showed a slight improvement over last year except in the case of dairy produce. The climate was also slightly more favourable.

There was a net profit of Rs. 15,626 during the year on the commercial side compared with Rs. 3,204 in the year 1931-32. This was mainly due to the climatic conditions being on the whole

more favourable than last year and also due to a rise in the market rate of wheat sold, and to a decline in the purchase price of the main articles of cattle rations.

There was a net decrease in capital assets mainly due to writing off annual depreciation. The decrease in receipts is due to less outlay on cultivation and dairying due to financial stringency.

The comparative figures of sale rates of dairy produce given below show a decrease :—

	1931-32 Rate per lb.	1932-33 Rate per lb.
Fresh milk	Rs. 0-1-0 to 0-1-6	Rs. 0-0-6 to 0-1-3
Butter table	Rs. 1-2-0 to 1-4-0	Rs. 1-0-0 to 1-4-0
Cream	Rs. 0-14-0 to 1-0-0	Rs. 0-12-0 to 0-14-0
Cream on butter outturn	Rs. 0-12-0	Rs. *0-10-0 to 0-11-0
Ghi	Rs. 0-8-9 to 0-12-0	Rs. 0-6-1 to 0-9-0
Separated milk	Rs. 0-0-6	Rs. 0-0-3 to 0-0-6
Cheese	Rs. 1-4-0 to 1-6-0	Rs. 1-2-0 to 1-6-0

*Wholesale on butter outturn to Military Dairy Farms or to others at Delhi or equivalent distances.

The disposal of milk or its products still remains a problem. The low local market rate precluded our selling to the public at Government sanctioned rates and the only alternative then was to separate the cream and sell to the Military Farms Department on the butter outturn and feeding the surplus separated milk to livestock. When, however, the Military Farms did not require as much cream as the farm produced, recourse had to be made to *ghi* manufacture which proved unremunerative owing to the low rate for *ghi* in the local districts.

The 1,981 acres of farm land was utilised approximately as follows :—

	Acres
Home cultivation	118·5
Batai cultivation	1,046
Grazing areas and waste land	261·5
Cash rental	298
Buildings and roads, etc.	257
	1,981

In the case of home cultivation the rotation followed was *juar* in the *kharif* season and wheat and gram in the *rabi* season (about 1/2 the area was down to wheat and half to gram). A small area of 4 acres was also sown with oats.

Wheat and gram are grown in the *rabi* season. The straw could be utilized as dry fodder for cattle and the grains can easily find a sale. Gram and wheat are sown in half the area of each plot, as it is difficult to get canal water if all the area is put down to wheat only.

The average outturn of crops is given below :—

Crops	Home outturn Mds. per acre	Batai outturn Mds. per acre	Remarks
Rice	*	12·8	In the case of Batai the outturn includes both the tenant's and Farm's shares.
Gram	23·5	11·6	
Oats	13·75	*	
Wheat Punjab 8-A	25·9	17·8	
Wheat Pusa 114	15·4	18·2	*Not sown.
Wheat 20-1	10·5	*	
Wheat Pusa 112	*	10·0	
Rice Straw	*	13·2	
Green *juar*	311·	Sold standing	
Bhusa wheat and gram	18·3	18·2	

Comparative yield of crops for the last three years is given below :—

Grains	1930-31	1931-32	1932-33
	Mds.	Mds.	Mds.
Rice	2,956	4,879	3,250
Wheat	3,796	2,985	3,580
Gram	4,058	4,022	5,731
Peas	132	124	..

Fodders	1930-31	1931-32	1932-33
	lb.	lb.	lb.
Green *juar* fed green	3,13,530	7,48,985	2,76,164
Dry *juar*	..	1,16,174	..
Green maize fed green	..	..	40,657
Dry maize (maize *kurby*)	..	..	7,180
Hay	1,23,155	76,138	1,18,476
Bhusa (gram and wheat)	12,71,103	6,28,604	6,98,694
Chari silage	45,19,260	58,70,123	15,51,840
Grass silage	..	..	1,68,388
Anjan grass seed	..	..	53
Green grass fed green	..	..	14,378
Poolas (thatching grass)	..	..	80½ mds.
Rice straw	2,15,373	6,28,604	3,332 mds.

The strength of the livestock of the farm at the beginning and the end of the year was as follows :—

	1-4-32	31-3-33
Cows	126	132
Buffaloes	13	12
Cow bulls	5	8
Buffalo bulls	1	2
Cow young stock males	109	53
Cow young stock females	101	108
Buffalo young stock males	9	3
Buffalo young stock females	23	7
Bullocks	24	26
Horse	1	1
Sheep—Ewes	93	32
Rams	6	4
Female lambs	93	66
Male lambs	46	2
Total	650	456

The reduction in numbers was due to retrenchment in young stock males and sheep at the beginning of the year.

One hundred and two cow calves and 14 buffalo calves were born during the year.

Up to the middle of February 1933, all calves having colour not true to its type were discarded. After that date some of the above class out of exceptionally high yielding dams and granddams are

being retained to experiment about their change of colour, etc. Some of the heifers and male calves of high yielding granddams are also retained which were discarded previously.

Up to the date mentioned in the previous paragraph, service to the cows was given after 3 months from calving, but it has been now regulated from first heat to 3 months, according to the number of calving, milk yield and condition of the animals. Heifers are covered between $2\frac{1}{2}$ and 3 years of age.

Feeding is done according to the approved scale of feed in consultation with the Physiological Chemist to the Government of India.

Breeding is carried on with a view to fixing high milking strains in all the three breeds on the farm. The majority of farm-bred heifers coming into the herd conform to the breed points and retain good milking qualities. The proportion of purchased animals has been reduced in a period of 10 years to 27 per cent. among cows and 25 per cent. among buffaloes. These include animals purchased from military dairy farms and provincial farms for basic stock.

Average milk yield of cows in a lactation, 1932-33

Breeds	Average milk yield	Average No. of days in milk	Average days dry
	lb.		
Tharparkar	4,035	272	99
Hariana	3,644	300	82
Buffaloes	4,741	299	104

A comparison of the over-all averages of the herd for three years shows improvement from year to year in all breeds. This is due to new farm-bred heifers coming into milk and weeding out of less profitable animals.

Over-all averages of different breeds

Year	Tharparkar	Percentage of increase over previous year.	Hariana	Percentage of increase over previous year	Buffaloes	Percentage of increase over previous year
	lb.		lb.		lb.	
1930-31	6·2	..	5·6	..	8·6	..
1931-32	7·8	26	7·6	35	10·4	22
1932-33	9·3	23	8·4	23	13·0	25

The six best animals of each breed to complete their lactation in 1932-33 were as follows :—

No.	Animal No.	Age	Milk yield during 1932-33	Days in milk	Remarks
		Yr. M.	lb.		
			Tharparkar		
1	119	14 0	7,708	386	
2	256	7 10	5,819	361	Farm bred.
3	272	8 0	6,755	307	,,
4	295	7 9	6,644	320	,,
5	306	6 6	7,005	336	,,
6	387	6 1	7,595	512	,,
			Hariana		
1	128	12 0	6,193	432	
2	142	12 9	5,417	279	
3	242	8 5	5,746	280	Farm bred.
4	302	7 2	6,567	305	,,
5	414	5 5	5,091	347	,,
6	423	5 2	5,097	366	,,
			Buffaloes		
1	10	13 0	5,421	306	
2	19	12 0	5,041	210	
3	21	7 7	4,414	200	Farm bred.
4	40	6 11	6,398	343	,,
5	45	5 10	7,598	463	,,
6	48	5 8	5,204	334	,,

Rearing of calves. As a general rule calves are weaned at birth and this has been successful in most of the cases. The hand-fed calves get mother's milk from birth up to a month and afterwards separated milk is added to their milk ration.

Mortality. One cow, 7 calves, 1 buffaloe-calf and 5 sheep died from natural causes. There was a mild outbreak of foot-and-mouth disease from the 7th May to the 5th June, 1932, and was confined

to cow young stock only. Fifty-one animals (5 cows, 45 cow young stock and 1 buffalo young stock) were inoculated against rinderpest. Except the nine older animals, all were done by the virus alone method. Eighteen cow young stock and three buffalo young stock were given rinderpest inoculations (virus alone method) by the staff of the Imperial Institute of Veterinary Research, Muktesar, to test the immunity of calves of protected and unprotected dams.

Herd testing for butter fat was undertaken under two heads from September, 1932 :—

(*i*) Tharparkar and Hariana cows mixed milk separately for each herd.

(*ii*) Each animal of both the breeds, from the date of calving to dry.

Under (*i*) only seven months tests are available which cover a part of the summer season and the whole of winter. Average cannot be taken yet unless the tests are taken for the complete year.

Under (*ii*) 51 animals, out of 132 heads (of both the breeds), have calved and their milk taken under testing and the rest would be brought under test as they calve. It will take at least one year more to arrive at conclusions; so far none of the animals has completed a lactation.

In December last, 12 samples of bazar mixed milk as sold by shopkeepers were obtained. It is generally believed by the public that it contains more of buffaloes milk than that of cows. Out of 12 samples, 4 were up to the mark as compared with dairy milk, and the rest were all below the standard. The highest test was 5·9 per cent. fat and the lowest 1·3 per cent. fat.

The Farm was visited during the year by 28 delegates of the Board of Agriculture and Animal Husbandry. The Professor of Agriculture, Punjab, and the Statistician, Imperial Council of Agricultural Research, also visited the farm. Students from the Khalsa College and also from the Punjab Agricultural College were shown round the farm.

A demonstration of an up-to-date dairy was arranged at the local Health and Baby Week.

Bangalore

Mr. S. Cox was in charge of the farm until the 5th April, 1933, when he proceeded on leave to England and Mr. A. Lamb assumed charge.

Owing to heavier and better distribution of rains during the cropping season, compared with the previous year, the outturn of farm grown fodder was more favourable and the cost of production thereby reduced.

The financial position under commercial activities shows an improvement as can be seen from the following figures :—

	1932-33	1931-32	1930-31
	Rs. A. P.	Rs. A. P.	Rs. A. P.
Profit . . .	18,253 8 0	1,238 12 1	1,000 7 2

This is due mainly to a decrease in the size of the herd entailing less expenditure on feed and keep. In addition, economies in expenditure were effected in other directions.

Receipts. Comparative figures for three years are as follows :—

1932-33	1931-32	1930-31
Rs. A. P.	Rs. A. P.	Rs. A. P.
1,16,560 10 3	1,27,077 3 2	1,27,720 1 6

(A reduction of 8·3 %).

The lower receipts during the year were mainly due to sales of dairy produce having been restricted, under Government orders, to the Military. The year under review being a resting year for coconut trees the rent of Rs. 4,500 for tapping was not also collected as was done in both previous years.

Trade. The sales of dairy produce in the first and second half of the year were as follows :—

	1st 6 months	2nd 6 months
	lb.	lb.
Milk	1,64,528	1,51,867
Butter	15,139	15,364
Cream	1,266	1,378
Cheese	504	494

The only item showing any large variation is milk and the decrease in sales of this article was due mainly to restriction of sales to the military.

Cultivation. The same policy continues as has been followed for many years, *i.e.*, to keep under a permanent green crop as much land as the water available for irrigation permits. This consists of about 9 acres of Guinea grass, ½ acre of Rhodes grass and 2/3 acre of lucerne. These crops give a continuous green fodder supply all the year round of considerable value to the herd.

The remaining cultivable area of 55 acres is used annually for a monsoon crop, usually *juar*, which is utilized largely forsilage making.

Rotation of crops is not followed as a general rule as plenty of farmyard manure is available and also because the harvesting of *juar* is usually too late to permit of a winter crop being sown. Experiments in this direction have met with little or no success. The only fodder purchased continually is *ragi* straw, a crop not grown on this farm. The outturn of fodder crops for the last two years is shown below :—

Kind of fodder	1932-33				1931-32	
	Acreage	Outturn in lb.	Total cost	Cost per 100 lb	Outturn in lb.	Cost per 100 lb.
			Rs. A. P.	Rs. A. P.		Rs. A. P.
Green *juar* . .	55·28	1,560,340	2,108 8 3	0 2 2	1,129,680	0 3 0
Green lucerne .	0·68	96,448	294 13 10	0 4 11	79,104	0 12 5
Green Guinea grass	9·03	968,460	1,892 11 0	0 3 2	1,039,450	0 4 3
Green Rhodes grass	0·46	79,600	111 13 2	0 2 3	..	..
Green grass .	..	..	..	..	..	..
	65·45	2,704,848	4,407 14 3	0 2 7	2,248,230	0 3 11
*Green *juar* .	..	2,83,355	319 9 10	0 1 10	242,300	0 2 9
* Green Guinea grass . .	..	8,400	..	..	7,000	..
		291,755	319 9 10	0 1 9	249,300	0 2 8
Grand Total .		2,996,603	4,727 8 1	0 2 6	2,497,530	0 3 9

* Grown at Bommanpally.

Cattle. The herds maintained consist of Scindis and cross-bred cows and a few Murrah buffaloes. In addition, 15 Gir cows and a bull were added in January 1933 as the nucleus of a Gir herd which it is intended to build up.

The feeding of the adult herd is based on the starch equivalent contained in the mixed concentrates, which consist of bran, groundnut cake, brewery grains and gram *chuni* in the proportion of 3 : 3 : 2 : 1. A pound of this mixture has a starch equivalent of 0·53 and the albuminoid ratio works out at 1 : 4·7.

Based on a live weight of 700 lb. and giving milk of 4·2 per cent. butter fat a cow gets 0·25 starch equivalent per pound of milk yielded *plus* ¾ pound of oil-cake for maintenance. Roughages are fed on a basis of 18 lb. dry matter fed as green fodder, silage or dry *ragi* straw in whatever proportions are available.

The comparative over-all averages of milk per day of all animals in the adult herd were as follows :—

	1932-33	1931-32	1930-31
	lb.	lb.	lb.
Cows (Cross-bred, Scindi and Gir).	9·6	8·6	8·1
Buffaloes	11·6	7·8	8·7

The following figures show the merits of the different classes of animals :—

	No.	Cross-breds	No.	Scindi	No.	Buffaloes
Average daily No. in herd milking .	..	70	..	51	..	8
Average daily No. in herd dry .	..	22	..	32	..	1
Average milk yield per animal which completed its lactation during the year	79	lb. 4,671	63	lb. 3,156	7	lb. 3,925
Average number of days in milk of the same animals . . .		307		281		316

As the breeding policy is to improve Indian breeds and to reduce the cross-bred herd gradually the Scindi and Gir cows are crossed only by selected bulls of their respective breeds.

Of the 164 animals sold during the year, the large majority were of the cross-bred type, particularly young stock.

Young stock. Thirty cross-bred and six Scindi heifers bred on the farm joined the adult herd during the year. In order to control services of young stock they are brought into the Bangalore Farm when about two years old and crossed by selected bulls, returning to the dry stock farm when in calf.

Dry stock. These are sent to the Dry Stock Farm at Bommanpally where they are kept until within a few weeks of calving when they are returned to Bangalore.

All these animals together with the young stock kept there are fed concentrates and fodder the whole year round, the grazing being very scanty even during the rains.

The dry stock farm is also used for inoculation purposes, the number inoculated by the serum simultaneous method against rinderpest last year being 13 cows and 66 young stock.

Diseases. Owing to an outbreak of rinderpest in a neighbouring village in May all unprotected animals in the herd at Bangalore were given one dose of serum. No further developments occurred.

In August a death at the Dry Stock Farm was suspected to be due to anthrax. All contact animals were protected at once and no further casualties occurred.

Filaria of the eye supposed to have been introduced by animals from Wellington occurred a number of times although most cases yielded to the treatment eventually. Mr. Raghunath Rao, a Veterinary Officer of Mysore Veterinary Department, has been particularly helpful throughout the year in the matter of inoculations and advice and his assistance is much appreciated.

The usual number of interested persons visited the Institute during the year including the Agricultural Chemist to the Government of Bombay and H. H. Rani Sahib of Palitana. Forty-nine students of the Agricultural College, Coimbatore, accompanied by a Lecturer in Chemistry, visited the Institute in January 1933.

Wellington

Mr. M. C. Rangaswamy, I. D. D., Supervisor, was in charge of the depot from April 1932 to November 1932 when he proceeded to Karnal to officiate as Assistant Superintendent. From December 1932 to the end of the year the depot was in charge of Mr. H. C. Verma, I. D. D., Supervisor.

During the year under review, the Institute worked as a quasi-commercial concern with education for a month and scientific investigations as its primary function and made a profit of Rs. 6,629 on its commercial side. In accordance with Government orders, it is now treated as a "depot" for the supply of dairy produce to Military stationed in its vicinity with the restriction that supplies are not made to civilians. As a result of this changed policy of working, cows in milk were supplied according to the requirements of the Institute by the Imperial Dairy Institute, Bangalore, and were returned to that place when dry.

Purchase prices were favourable during the year. The total rainfall was a little less than in preceding years, as is shown below. Shortage of rainfall during the *rabi* season was responsible for the decreased outturn of *rabi* crops. The weather conditions during the rest of the year were normal.

Rainfall for last 3 years	Inches
1932-33	50·34
1931-32	58·41
1930-31	55·37

Receipts. In general, the total receipts of the year under review indicate a drop of 45·3 and 58·3 per cent. from the two preceding years respectively. The main reason for this large decrease was the restriction made in supplying dairy produce to the Military only.

Establishment. The expenditure under this head amounted to Rs. 10,487, as against Rs. 21,914 in the previous year. This large decrease was due to the retrenchment of the post of Superintendent which was replaced by a Supervisor-in-charge on a much smaller scale of pay, and reduction in subordinate establishment.

Trade. Sales of chief dairy products for the second half of the year under review, with the second halves of the two years immediately preceding it, are compared in the table below :—

	1932-33	1931-32	1930-31
	lb.	lb.	lb.
Milk	63,893	84,173	133,429
Butter	8,160	9,565	9,665
Cream	276	218	173

The considerable drop in sales is to be ascribed to the restriction of supplies to the military.

The purchase prices of wheat, bran and ground-nut cake were higher than in 1931-32. Prices of gram husk and gram being lower, contributed to decrease the average purchase price of all concentrates combined. Paddy straw was the only dry fodder purchased during the year, as it is a necessary food for cattle and cannot be produced at the Institute.

Cultivation. The table given below shows particulars of land in acres, owned and leased by the Institute during the year under review :—

	Arable Perennials	Arable Seasonal crops	Grazing	Forest for fuel	Buildings and roads	Total
Owned . .	5·5	28·65	21·61	7·0	6·08	68·84
Leased . .	..	5	*90·01	..	..	95·01
Total .	5·5	33·65	111·62	7·0	6·08	163·85

*90·01 acres of leased land include 86·01 acres of land rented for only 4 months in the year.

The following table shows how the arable land indicated above was distributed for cultivation, and the rotation that was followed :-

	Acres	*Kharif*	*Rabi*
(*a*)	5	Perennial . .	Rhodes and Guinea grass.
(*b*)	½	,, . .	Lucerne.
(*c*)	2½	Potato . .	Wheat and cabbage.
(*d*)	1½	*Juar* . .	Potato.
(*e*)	13½	,, . .	Oats and *ragi*.
(*f*)	14	Maize . .	Oats.
(*g*)	2·15	*Bajra* . .	Oats and mangolds.
	39·15		

The table given below shows comparative yields of crops for the last three years :—

	1932-33	1931-32	1930-31
	lb.	lb.	lb.
Rhodes grass and Guinea grass	138,555	177,115	116,020
Lucerne	15,435	..	6,475
Maize	108,990	118,210	20,800
Juar	126,655	52,125	116,710
Sun-flower	2,400	..	..
Bajra	19,900	12,070	..
Wheat	11,535	..	..
Oats	58,140	236,305	138,790
Ragi	1,700	32,435	..
Cabbage	8,800	14,285	..
Mangolds	520	..	..
Total available food for cattle	492,630	642,545	398,795
Potatoes (Cash crop)	33,384	38,090	57,010
Total	526,014	680,635	455,805

The seasonal crops most suitable in this part are maize, *juar*, oats and wheat for the supply of green fodder, with occasional supplementing with cabbage, mangolds, *ragi* and *bajra*. These give large yields and are economical to grow. During the year under review, green fodder was produced at 0-8-1 per 100 lb. as against the market rate of about rupee one for the equivalent quantity.

Guinea grass, Rhodes grass and lucerne form good perennials and yield a continuous supply of green fodder throughout the year.

The most remunerative cash crop is the potato. Several varieties such as Early Market, Arran, Comrade, King Edward and Great Scot are grown. During the year under review an outturn of about 14,000 lb. per acre was obtained at the production cost of about 13 annas per 100 lb. The following table shows comparative sale prices of potatoes for the last three years. It will be seen that although the sale price of potatoes during the year fell considerably, yet the profit made on every 100 lb. was more than Rs. 1-12-0 :—

	Sale price Rs. Per 100 lb.
1932-33	2 9 5
1931-32	5 1 7
1930-31	3 5 7